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13. ABSTRACT *(Maximum 200 Words)*

This study updates the findings of a January 1992 study addressing possible uses of unmanned ground vehicles (UGVs) on the battlefield. The 1992 study was in support of the UGV Joint Project Office (JPO) and was conducted to assist the USMC and the Army in developing joint requirements for a UGV. These requirements were promulgated in the *Marine Corps Mission Need Statement (MNS) for a Tactical Unmanned Ground Vehicle (TUGV)* in the joint Army/Marine Corps *Operational Requirements Document (ORD) for the Tactical Unmanned Vehicle (TUV)*. However, since publication of the 1992 study, the Marine Corps has developed new warfighting concepts incorporating maneuver warfare principles into expeditionary operations from the sea. This study reflects changes in Marine Corps requirements for UGVs based on these new warfighting concepts.

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SPONSOR'S LETTER OF INTENT FOR THE UPDATE OF THE UNMANNED GROUND VEHICLE FINAL REPORT

(1) CG MCCDC Letter of Distribution
(2) Final Report

Ref: (a) MCO P3902.1B

1. This study was conducted under the auspices of the Marine Corps Studies System per the reference. The purpose of this study was to revise the January, 1992 MCCDC report *Unmanned Ground Vehicle Final Report* to reflect the changes in Marine Corps warfighting concepts since the original report was published. The subject study has been completed, and the objectives of the study have been met.

2. Background. In January, 1992, the Marine Corps Combat Development Command (MCCDC) commissioned PRC, Inc. (a military analysis contractor) to study the near and far-term uses of Unmanned Ground Vehicles (UGV's) in support of the UGV Joint Project Office. The study identified warfighting missions that UGV's can effectively perform based on technological capabilities and identified deficiencies. The purpose of the report was to assist the USMC and the Army in developing the joint requirements for a new Tele-operated Unmanned Ground Vehicle (TUGV). Currently, the USMC believes that the mission requirements of the two services have diverged sufficiently such that the generation of a USMC-specific Operational Requirements Document (ORD) is justified.

3. Study Objectives: The specific objective of the study was re-examine the potential uses of Unmanned Ground Vehicles in the USMC and to revise the existing study report in light of technological advances and changes in USMC operational concepts.

4. RESULTS. The results of the study clearly indicate that there are many functions that can be performed by UGVs to enhance the ability of tactical commanders to rapidly detect, identify, locate, and neutralize a variety of threats. This study, along with the results of the current Gladiator Concept Validation Model (CVM), will help validate and shape the Gladiator ORD into a realistic document that will guide the design of the final Gladiator system.

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EXECUTIVE SUMMARY

Background. This study updates the findings of a January 1992 study addressing possible uses of unmanned ground vehicles (UGVs) on the battlefield. The 1992 study was in support of the UGV Joint Project Office (JPO) and was conducted to assist the USMC and the Army in developing joint requirements for a UGV. These requirements were promulgated in the *Marine Corps Mission Need Statement (MNS) for a Tactical Unmanned Ground Vehicle (TUGV)* in the joint Army/Marine Corps *Operational Requirements Document (ORD) for the Tactical Unmanned Vehicle (TUV).* However, since publication of the 1992 study, the Marine Corps has developed new warfighting concepts incorporating maneuver warfare principles into expeditionary operations from the sea. This study reflects changes in Marine Corps requirements for UGVs based on these new warfighting concepts.

Scope. This study effort updated the 1992 study in the following areas: the threat; the documented and undocumented deficiencies; the technological opportunities; and the notions of employment (NOEs), theories of employment (TOEs), and concepts of employment (COEs).

Updated Threat. The study team updated the threat based on the current Marine Corps Mid-Range Threat as well as national security documents and open source literature. The threat section addresses the threat that UGVs are designed to counter as well as the threat to UGVs. The updated threat analysis was taken into account when developing NOEs, TOEs, and COEs.

Updated Documented Deficiencies. The documented deficiencies in the original study were based on the *MAGTF Master Plan 1990-2000* and the *TRADOC Battlefield Development Plan 1989*. The study team updated the documented deficiencies in the original report based on an analysis of the *Marine Corps Master Plan for the 21st Century* and the required capabilities identified in Marine Corps mission area analyses (MAAs). Of the 36 capabilities in the Master Plan (see Appendix D of this report for a complete list of the operational and support capabilities identified in the Master Plan) eleven describe capabilities that might, at least in part, be attained through the employment of UGVs. In addition, 17 required capabilities identified through the MAA process could be addressed through employment of UGVs. These capabilities are found at Table 1 in the basic report.

Updated Undocumented Deficiencies. The undocumented deficiencies in the original study were based on interviews, surveys, and a literature search. The study team updated the undocumented deficiencies based upon current Marine Corps warfighting concepts. The study team analyzed *Operational Maneuver from the Sea* (OMFTS) and each of 11 supporting warfighting concepts to identify the improvements needed in Marine air-ground task force (MAGTF) operational capabilities to implement the concepts. These needed capabilities were defined as undocumented deficiencies. A total of 123 such deficiencies were identified and categorized by warfighting function (see Table 2 of the basic report).

Updated Technological Opportunities. The original study identified technological opportunities through literature search, interviews, surveys, and site visits. The study team updated the technological opportunities by reviewing the results of ongoing technology initiatives and the performance of prototype systems in demonstrations, exercises, and operational employment. Section 3.4 of the report provides the results of this review, identifying numerous ongoing UGV programs of interest to the Marine Corps. As part of this review of technological opportunities, the study team visited the Unmanned Ground Vehicle/System (UGV/S) JPO. The UGV/S JPO coordinated an assessment of the availability of technology to support each NOE. The results of that assessment are contained at Appendix E to the attached report.

Updated NOEs. The original report defined NOE as "An idea or vision, for using a UGV to accomplish a military mission, battlefield task, or tactical function, that might lead to an accepted military procedure." In the original study, NOEs were developed by examining warfighting deficiencies to determine which could be addressed by UGV employment and by taking into account the opportunities offered by technology. The study team used a similar process to develop a set of NOEs addressing the updated deficiencies. A total of 55 NOEs were developed. Table 3 of the report presents these NOEs, categorized by warfighting function, and identifies the documented and undocumented deficiencies supported by each NOE.

Updated TOEs. The original report defined TOE as "A NOE that has been refined, made more specific, and often incorporated with other, similar NOEs, and withstood the rigors of the analysis and prioritization process." In the original study, NOEs were prioritized by a multiattribute utility technique using a modified Delphi approach to weight attributes and to score NOEs with respect to each attribute. In updating the TOEs, the study team employed a similar multiattribute utility approach to prioritize NOEs. However, a somewhat more rigorous technique, the analytic hierarchy process (AHP), was used to determine weights for attributes and no attempt was made to attain group consensus in scoring NOEs. Appendix F describes the prioritization process. The rank-ordered NOEs were defined as TOEs and are presented in Table 4 of the report.

Updated COEs. In the original study a seminar wargame was used to analyze and validate the highest-ranking TOEs and to support the refinement of TOEs into COEs. In this update, wargaming was not used to validate and develop COEs. Discussions with current and former Marines, as well as government and contractor personnel involved in UGV research and development (R&D), took the place of the wargaming conducted in support of the original study. The 15 top-ranking TOEs (rank-ordered NOEs as determined through the prioritization process) were selected for refinement into 13 COEs. Based on similar operational and organizational profiles, an additional seven lower-ranking TOEs were incorporated into the 13 COEs. TOEs were incorporated into COEs based on how and by whom the UGV will be employed as well as by the nature of the tasks to be performed. In all cases COEs were developed from a functional vice a design perspective. The COEs and their associated NOEs are listed in Table ES-1 below. It is important to note that the process of developing COEs removes the rank order that was

associated with the individual NOEs. This study does not develop a rank order or a relative priority among COEs.

Summary. The last section of the study integrates the COEs, developed by the study team, with the technology assessment, coordinated by the UGV/S JPO. The technology assessment estimated the technological maturity of each of the NOEs in each of five areas: intelligence, sensors, mobility, C3, and Marine machine interface (MMI). Scores were assigned as levels one through four, with one being the least mature and four being the most mature. The level of technological maturity was assigned based on where that particular technology stood in the research and development cycle. A one was assigned for technology in basic research, a two for technology in applied research, a three for technology in advanced development, and a four for technology in engineering and manufacturing development.

Table ES-1 depicts the maturity level assigned in each of the five technology areas for each of the 13 COEs. The intelligence technology area, which includes perception and cooperative behavior, is generally assessed at level one for COEs requiring autonomous operation and level four for COEs using teleoperation. Similarly, for the sensor technology area, the maturity level is significantly lower for those COEs requiring autonomous operation. The mobility technology area, while in general more mature than the first two areas, is still not mature enough to fully support any of the COEs. The maturity levels of the last two technology areas, C3 and MMI, with only a few exceptions, are equal to or greater than the maturity levels of the other three technology areas. As shown in Table ES-1, none of the COEs were assessed as level four in all technology areas (based on the technology level of associated NOEs). However, three of the COEs were assessed as level three or above in all technology areas. Based on the technology assessment, it appears that these COEs (Communications Relay, Antipersonnel Obstacle and Minefield Breaching, and Neutralizing Fortified Positions) would pose the least technological risk in development and fielding.

Table ES-1. Technological Maturity

COE Title	NOE #	NOE Title	Technological Maturity				
			INTEL	SENSORS	MOBILITY	C3	MMI
Communications Relay	1	Communications Relay	4	3	3	3	3
Nuclear, Biological, and Chemical Reconnaissance	2	Nuclear, Biological, and Chemical Reconnaissance	2	2	2	3	3
Antipersonnel Obstacle and Minefield Breaching	3	Antipersonnel Obstacle and Minefield Breaching	4	4	3	4	4
Point for Infantry	4	Point for Infantry	4	3	2	3	2
	7	Close Reconnaissance	4	4	3	4	3
Building Reconnaissance, Clearance, and Surveillance	5	Building Reconnaissance and Clearance	2	2	2	3	3
	26	Building Reconnaissance and Surveillance	2	2	2	3	3
Robotic Surveillance and Target Acquisition	6	Robotic Forward Observer/Target Designator	2	2	3	2	3
	20	Surveillance	1	1	3	1	2
	34	Landing Zone Security	1	2	3	3	3
Robotic EOD Operations	8	Bomb Detection/Disposal	4	2	3	3	3
Route Reconnaissance	9	Route Reconnaissance	2	2	2	3	3
Small-Unit Base of Fire	10	Rifle Squad/Fire Team Base of Fire	4	3	3	3	2
Remote EW Operations	11	Electronic Warfare	1	2	2	3	3
Neutralizing Fortified Positions	12	Assault on Fortified Positions	4	4	3	4	3
	46	Robotic Flamethrower	4	4	4	3	4
Combat Patrolling	13	Combat Patrolling	2	2	2	3	3
	45	Covering Force	1	2	2	2	3
	47	Remote Attack/Ambush	1	2	2	2	3
Urban Operations	14	Urban RSTA	4	3	2	3	3
	15	Urban Warrior	4	3	2	2	2
	21	Countersniper	4	2	2	2	2

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1. INTRODUCTION

1.1 Background. In January 1992, a study was completed addressing the near- and far-term uses of unmanned ground vehicles (UGVs). The Marine Corps Combat Development Command (MCCDC) directed the study in support of the UGV Joint Project Office (JPO). The purpose of the study was to identify warfighting missions that UGVs could perform effectively based on evolving robotics and teleoperator technology and identified deficiencies in warfighting capabilities. The purpose of the report was to assist the U.S. Marine Corps (USMC) and the U.S. Army (USA) in developing the joint requirements for a new teleoperated unmanned ground vehicle. These requirements were promulgated in the *Marine Corps Mission Need Statement (MNS) for a Tactical Unmanned Ground Vehicle (TUGV)* published 10 November 1993 and in the *Operational Requirements Document (ORD) for the Tactical Unmanned Vehicle (TUV).* The ORD is a joint document published by USA Training and Doctrine Command (TRADOC) on 16 August 1994 and by the Marine Corps on 7 May 1996. Since the publication of the UGV study, the Marine Corps has developed new warfighting concepts incorporating maneuver warfare principles into expeditionary operations from the sea. The Marine Corps directed an update of the original UGV study to reflect changes in Marine Corps requirements for UGVs based on these new warfighting concepts.

1.2 Scope and Objective. This study re-examines the potential uses of UGVs in the Marine Corps in light of technological advances and changes in Marine Corps operational warfighting concepts. Based on this re-examination, the findings of the original study report have been revised.

1.3 Assumptions

- The Marine Corps mission, as prescribed in the National Security Act of 1947 (amended), will not change from FY 2001 to FY 2005.
- The force programmed in the current Program Objectives Memorandum will be subject to change.
- Threat forces will continue to modernize in accordance with the projections of our intelligence agencies.
- An environment of stable defense budgets will likely continue for the foreseeable future.
- The operational tempo that the Marine Corps is currently experiencing will remain the same for the foreseeable future.

1.4 Methodology. The statement of work (SOW) required that the findings of the original UGV study be updated. These findings consisted of the threat, documented deficiencies, undocumented deficiencies, technological opportunities, notions of

employment (NOEs), theories of employment (TOEs), and concepts of employment (COEs).

1.4.1 Updating the Threat. The original study based the threat on reviews of unclassified government documents and open source literature as well as interviews. The study team updated the threat described in the original report based on the current Marine Corps Mid-Range Threat as well as national security documents and open source literature. The threat addresses the threat that UGVs are designed to counter as well as the threat to UGVs. The results of the threat analysis were taken into account when developing NOEs, TOEs, and COEs.

1.4.2 Updating Documented Deficiencies. The documented deficiencies in the original study were based on the *MAGTF Master Plan 1990-2000* and the *TRADOC Battlefield Development Plan 1989*. The study team updated the documented deficiencies in the original report based on an analysis of the *Marine Corps Master Plan for the 21st Century* and the required capabilities identified in Marine Corps mission area analyses (MAAs).

1.4.3 Updating Undocumented Deficiencies. The undocumented deficiencies in the original study were based on interviews, surveys, and a literature search. The study team updated the undocumented deficiencies based upon current Marine Corps warfighting concepts. The study team assessed how UGVs might provide needed capabilities to successfully implement each of the warfighting concepts.

1.4.4 Updating Technological Opportunities. The original study identified technological opportunities through literature search, interviews, surveys, and site visits. The study team updated the technological opportunities by reviewing the results of ongoing technology initiatives and the performance of prototype systems in demonstrations, exercises, and operational employment. As part of this review, the study team visited the Unmanned Ground Vehicle/System (UGV/S) JPO. The UGV/S JPO coordinated an assessment of the availability of technology to support each NOE. The results of that assessment are contained at Appendix E.

1.4.5 Updating NOEs. The original report defined NOE as "An idea or vision, for using a UGV to accomplish a military mission, battlefield task, or tactical function, that might lead to an accepted military procedure." In the original study, NOEs were developed by examining warfighting deficiencies to determine which could be addressed by UGV employment and by taking into account the opportunities offered by technology. The study team used a similar process to develop a set of NOEs addressing the updated deficiencies.

1.4.6 Updating TOEs. The original report defined TOE as "A NOE that has been refined, made more specific, and often incorporated with other, similar NOEs, and withstood the rigors of the analysis and prioritization process." In the original study, NOEs were prioritized by a multiattribute utility technique using a modified Delphi approach to weight attributes and to score NOEs with respect to each attribute. Total

scores were derived from summing the results of multiplying attribute weights by attribute scores and, based on total scores, a relative priority ranking of NOEs was developed. At this point, lower-ranking NOEs were discarded from consideration. The remaining NOEs were considered TOEs. In updating the TOEs, the study team employed a similar multiattribute utility approach. However, a somewhat more rigorous technique, the analytic hierarchy process (AHP), was used to determine weights for attributes, and no attempt was made to attain group consensus in scoring NOEs.

1.4.7 Updating COEs. In the original study a seminar wargame was used to analyze the highest-ranking TOEs. The wargame was used to eliminate impractical NOEs and to highlight the most promising concepts for employment of UGVs on the battlefield. As a result of the wargaming analysis, nine "validated" COEs were published in the study report. Based on SOW guidance, in this update wargaming was not used to screen and prioritize NOEs for conversion into COEs. Instead, the 15 highest-ranking TOEs (TOEs are NOEs ranked as described in paragraph 1.4.6 above) were selected for refinement and consolidation into COEs. Discussions with current and former Marines, as well as government and contractor personnel involved in UGV research and development (R&D), took the place of the wargaming conducted in support of the original study. Based on similar operational and organizational profiles, some lower-ranking TOEs were also incorporated into the COEs. In the process of refining and consolidating, any rank order associated with individual NOEs was lost. The study did not develop a relative priority or rank order for the COEs.

2. LITERATURE SEARCH AND INTERVIEWS

The government SOW named *Operational Maneuver from the Sea (OMFTS)* and eleven of its supporting concepts as references for the update of the UGV study. In addition to these warfighting concepts, the study team reviewed numerous national, Department of Defense (DoD), and Marine Corps strategic policy and planning documents to obtain insight into how UGVs might contribute to the role of the Marine Corps in our national defense. The study team also reviewed UGV program documentation including the Joint Robotic Program (JRP) Master Plan and Marine Corps UGV-related requirements documents. The original UGV report was thoroughly reviewed and carefully analyzed. A full listing of the documents reviewed is contained in the bibliography at Appendix A. The study team also conducted a number of information-gathering visits and interviews including a trip to the UGV/S JPO at Redstone Arsenal.

2.1 Literature Search. A number of the documents reviewed by the study team are particularly significant in terms of their relevance to employment of UGVs by the Marine air-ground task force (MAGTF).

- ***A National Security Strategy for a New Century*.** This document was the current version of the National Security Strategy as this report was written. The strategy is one of forward engagement emphasizing America's role in promoting peace and prosperity throughout the world. The global environment described envisions asymmetric threats from states and transnational organizations, both of which are

viewed as having the capacity to acquire and employ weapons of mass destruction (WMD). The strategy highlights the need for our military forces to operate effectively in the face of this threat. This includes the requirement for adequate force protection in smaller scale contingencies (SSCs) and in major theater wars (MTWs).

- ***National Military Strategy of the United States of America*.** The National Military Strategy implements the guidance contained in the National Security Strategy--to remain globally engaged to shape the international environment and create conditions favorable to U.S. interests and global security. The National Military Strategy describes *Joint Vision 2010* as the conceptual template for future warfighting. Of particular relevance to the employment of UGVs on future battlefields is the emphasis on force protection contained in the following paragraph taken from the strategy:

  > *Multiple layers of protection for US forces and facilities at all levels, beginning at home, enable US forces to maintain freedom of action from predeployment through employment and redeployment. Fluid battlefields and the potential ability of adversaries to orchestrate asymmetric threats against our forces require that we seek every means to protect our forces. Comprehensive force protection requires the employment of a full array of active and passive measures. The variety of challenges that we will face may also require less than lethal technology to meet demands at the lower end of the range of military operations. Force protection initiatives must thus address all aspects of potential threats, to include terrorism, weapons of mass destruction (WMD), information operations, and theater ballistic and cruise missiles.*

- ***Joint Vision 2010*.** *Joint Vision 2010*, published in June of 1997 under the signature of the Chairman of the Joint Chiefs of Staff, describes a vision of how the joint forces will conduct future operations across the conflict spectrum. It talks in terms of four operational concepts: dominant maneuver, precision engagement, full dimensional protection, and focused logistics. *Joint Vision 2010* identifies technological innovation as instrumental in enabling the joint force to implement these operational concepts. Among the initiatives discussed to improve operational capabilities through exploitation of technology is the use of Advanced Capabilities Technology Demonstrations (ACTDs).

- ***Joint Vision 2020*.** *Joint Vision 2020*, published in June of 2000, reiterates the themes of *Joint Vision 2010*. It places tremendous emphasis on full dimensional protection against a wide range of threats--conventional and unconventional, symmetric and asymmetric. As does *Joint Vision 2010*, *Joint Vision 2020* highlights the role of technological innovation in developing the required operational capabilities to implement the vision.

- ***Quadrennial Defense Review* (QDR).** The report of the QDR was released in May 1997. It is basically an endorsement of *Joint Vision 2010* and dovetails with the current National Military Strategy.

- ***Transforming Defense: National Security in the 21st Century*.** This is the report of the National Defense Panel. The National Defense Panel is an independent, congressionally mandated board chartered to review the QDR. By and large the National Defense Panel endorsed the work of the QDR. However, it did critique the work of the QDR in several areas. Of particular interest, with respect to potential employment of unmanned ground vehicles, was the following paragraph taken from the document: "As new technologies mature, very different operational concepts will be feasible and they will lead to demands for quite different forces and equipment. As a result, the fairly conventional approaches used in the QDR's MTW assessments may not generate an optimal force structure." In other words, the National Defense Panel believed that the QDR was too conservative in terms of exploiting technological opportunity. The report states that "Technology will play an ever-increasing and imperative role in America's security policy and programs in the future. Robotics and unmanned vehicles will become a part of everyday life, both in the military and society at large." Also of interest, from the standpoint of developing concepts for employment of UGVs, are the specific recommendations that the National Defense Panel made for improving power-projection capabilities:

    - New approaches and thinking about power projection and our asymmetric capabilities.

    - Smaller forces with greater lethality supported by leaner logistics.

    - Widely dispersed ground units characterized by speed of execution and ability to concentrate at strategic points.

    - Small units such as special operations forces and other ground teams specializing in deep reconnaissance.

    - Distributed and networked battle fleets from which air, land, and sea attacks are launched.

    - Air forces with greater emphasis on operating at extended ranges with tactical air and long-range aircraft and unmanned aerial systems.

    - Both offensive and defensive measures to reduce WMD vulnerability of deployed forces.

    - Expanded research and development focused on urban warfare issues.

- ***Letter of Instruction (LOI) for the Joint Robotics Program (JRP).*** The JRP LOI was promulgated on 1 September 2000 in an attempt to clarify the roles and responsibilities of the managers and offices that comprise the JRP. The stated purpose of the LOI is to "... ensure proper coordination, to avoid duplication of effort, and to ensure the efficiency and functioning of the JRP and its elements."

- ***FY 2000 JRP Master Plan*.** The JRP Master Plan is prepared annually and submitted to Congress. It describes ongoing efforts under the JRP to develop and field mobile ground robotic systems. It includes descriptions of all JRP efforts as well as related DoD unmanned ground vehicle efforts that are funded outside of the JRP. The study team used the JRP Master Plan as the primary source document for the identification of ongoing technology initiatives and research, development, and acquisition projects. The study team also used the Master Plan as the source of UGV-related definitions found at Appendix C.

- **Future Naval Capabilities.** The Future Naval Capabilities process was instituted in 1998 to guide naval science and technology investment toward a focus on the development of future operational capability. The result of the process was a set of 12 future naval capabilities. These capabilities include a capability for autonomous operations with eight subcategories:

  - 1--Provide access to areas of responsibility through organic unmanned systems that can be dynamically retasked.
  - 2--Enable automated surveillance and reconnaissance in all environmental conditions.
  - 3--Enable automated surveillance and reconnaissance data processing.
  - 4--Enable secure, jam-resistant sensor-to-shooter-to-weapon connectivity.
  - 5--Minimize human intervention and enable manned/unmanned platform operations and interoperability.
  - 6--Enable unmanned mine clearance operations.
  - 7--Enable electronic attack, platform protection, and force protection through the use of unmanned systems.
  - 8--Enable expeditionary logistics with unmanned systems.

  The autonomous operations program is sponsoring a number of technology initiatives designed to identify, demonstrate, and transition into acquisition programs the technology necessary for the Marine Corps to field operationally effective UGVs.

- ***Unmanned Ground Vehicle Final Report*.** The UGV report, completed in January 1992, was a study of the potential near-term and far-term uses of UGVs by the Army and the Marine Corps. The study was conducted in support of the UGV JPO. The purpose of the study was to identify warfighting missions that UGVs could perform effectively based on evolving technology and identified deficiencies in warfighting capabilities. The report was instrumental in helping the USMC and the Army develop the joint requirement for the TUGV. As discussed in the introduction, the study team was tasked to revise this report in light of technological advances and changes in USMC operational warfighting concepts.

- ***Marine Corps Master Plan for the 21st Century*.** The *Marine Corps Master Plan for the 21st Century* is based upon guidance from the National Security Strategy and the

National Military Strategy and establishes the Marine Corps vision for operations in the 21st Century. The Master Plan defines six core competencies:

- Expeditionary readiness
- Combined arms operations
- Expeditionary operations
- Seabased operations
- Forcible entry from the sea
- Reserve integration.

The Master Plan provides direction to the Commanding General, MCCDC, for the development of needed combat capabilities for the Marine Corps to maintain core competencies in the 21st Century. It identifies 36 "Required Operational and Support Capabilities" and assigns responsibilities to HQMC, the supporting establishment, and the operating forces for ensuring the attainment of these 36 capabilities.

- ***Marine Corps Strategy 21.*** *Marine Corps Strategy 21*, like the Master Plan published three years earlier, is intended to provide vision and direction for the Marine Corps of the 21st Century based upon tasks derived from the guidance in the National Security Strategy and the National Military Strategy. Strategy 21 also references *Joint Vision 2010* and *Joint Vision 2020* as guiding documents. The strategy states that the Marine Corps will "...provide the National Command Authorities and combatant commanders with Marine forces that promote peace and stability through forward presence and peacetime engagement, respond across the complex spectrum of crises, and, as part of or leading a joint or multinational force, defeat our Nation's adversaries." *Marine Corps Strategy 21* sets three major goals:

  - Make America's Marines the premier expeditionary "Total Force in Readiness."
  - Optimize the Corps' operating forces, support and sustainment base, and unique capabilities to respond to the complex spectrum of crises and conflicts.
  - Capitalize on innovation, experimentation, and technology to prepare Marine Forces to succeed in the 21st Century.

  Each of these goals is supported by a number of "aims" intended to focus efforts toward attainment of the goals. Four aims under the second goal would appear to be particularly relevant to the development of concepts for employment of UGVs:

  - Expand capabilities to observe, visualize, and shape the operational area and to attack enemy critical vulnerabilities leading to the defeat of the enemy's operational and tactical centers of gravity.

  - Enhance responsive, integrated, and balanced expeditionary fires leveraging improvements to organic surveillance, target acquisition, aviation, and indirect fires, naval fire support, and joint fires.

- Enhance capabilities to operate in urban and austere environments across the spectrum of conflict while simultaneously further reducing our dependence on existing infrastructure.

- Provide DoD with a fully integrated and coordinated nonlethal weapons program based upon flexible and selective engagement capabilities.

The third goal, in and of itself, supports the development of concepts for UGV employment: "...capitalize on innovation, experimentation, and technology.…" Several of the aims under the third goal further suggest specific areas to be addressed:

- Ensure access to the littorals through evolving expeditionary operations (to include mine and obstacle countermeasures, naval surface fires, etc.), maritime prepositioning, national sealift, high-speed troop lift, and naval aviation capabilities.

- Provide rapid and precise distribution of tailored expeditionary logistics to the operating forces in any operational environment.

- ***Marine Corps Midrange Threat Estimate - 1997-2007*.** The Marine Corps Midrange Threat Estimate, prepared by the Marine Corps Intelligence Activity (now the Marine Corps Intelligence Command), assesses the threat to Marine Corps forces conducting expeditionary operations in the period 1997-2007. The estimate was developed to support the development of Marine Corps policy and programs including doctrine, training and education, force structure, acquisition, and resource allocation.

- ***Operational Maneuver from the Sea (OMFTS).*** OMFTS is the capstone operational concept of the Marine Corps. Together with its supporting concepts, OMFTS describes how MAGTFs will conduct expeditionary operations, both combat and noncombat, in response to any contingency. As the title OMFTS implies, the thrust of the concept is operational maneuver--the employment of the MAGTF as an operational-level force in such a way as to gain and exploit an operational advantage. OMFTS seeks to fully exploit the naval character of Marine Corps forces--the ability to forward deploy at sea near a crisis, project power ashore, sustain forces ashore from a seabase, and redeploy to the sea. Implementation of OMFTS is dependent upon a number of supporting concepts as discussed below.

- ***Ship-to-Objective Maneuver (STOM).*** STOM is the underlying concept for the conduct of amphibious operations in support of OMFTS. The STOM concept applies maneuver warfare concepts to the littoral battlespace. STOM seeks to pit strength against the enemy's weaknesses by avoiding littoral defenses and exploiting gaps in those defenses. The landing force maneuvers directly from over the horizon by both vertical and surface assaults against objectives deep inland. There is no operational pause to build up combat power ashore prior to proceeding to MAGTF objectives. The STOM concept is enabled by improvements in the MAGTF's mobility, specifically the fielding of the MV-22 Osprey and the advanced assault amphibious

vehicle (AAAV). However, full implementation of the STOM concept also hinges on the ability of the MAGTF to seabase command and control (C2), fire support, logistics, and aviation.

- ***Maritime Propositioning Force (MPF) - 2010 and Beyond*.** The MPF 2010 concept envisions MPF forces capable of responding to and participating in a wider range of contingency operations. MPF 2010 will fully support OMFTS through rapid reinforcement of forward-deployed amphibious forces. The MPF 2010 concept permits a marriage of troops and equipment at sea and, through selective offload, subsequent reinforcement of the assault echelon of an amphibious task force. At the same time the MPF 2010 concept provides an improved capability to conduct current MPF missions--rapid projection of maritime prepositioned combat power and long-term sustainment of forces ashore. MPF forces will no longer depend on the availability of secure ports and airfields to conduct operations. The MPF will arrive in the area of operations fully prepared to conduct operations. Improved offload capabilities will negate the need for securing port facilities prior to conducting MPF operations.

- ***Sustained Operations Ashore (SOA).*** The SOA concept envisions the MAGTF as a seabased operational maneuver element supporting a joint task force. The concept does not foresee the MAGTF becoming bogged down in a sustained land campaign and places emphasis on retaining the flexibility offered by operations from a seabase. The MAGTF commander will exploit the seabased nature of his force to execute precise, focused combat actions, rather than participate in continuous, drawn-out ground operations.

- ***Beyond C2: A Concept for Comprehensive Command and Coordination of the Marine Air-Ground Task Force*.** One of the implementing concepts of OMFTS, this concept develops a command and control theory based upon Marine Corps maneuver warfare philosophy. The concept envisions replacing centralized forms of "control" with broad "coordination" techniques. These techniques embrace such ideas as commander's intent, mission orders, implicit communications, and mutual understanding. The concept summarizes the approach as follows: "The aim of MAGTF command and coordination is to empower commanders at every level to focus resources upon a mission, while enabling the inventiveness and initiative of subordinates."

- ***Advanced Expeditionary Fire Support*.** This concept describes a fire support capability effective across the entire spectrum of conflict. The concept envisions responsive, all-weather fire support ranging from devastatingly lethal fires required in major theater wars to tailored, nonlethal fires required in smaller scale contingencies. OMFTS and SOA operations in MTW scenarios and SSCs will place severe demands on fire support capabilities available to the MAGTF. OMFTS operations will initially require that all fire support come from a seabase in the form of naval surface fire support and naval aviation. Even after the STOM is well underway and the maneuver elements of the landing force are ashore, only limited fire support assets will be

ashore and these shore-based assets must not adversely impact the mobility of the maneuver elements they accompany. Furthermore, in SOA, the fire support system must be able to provide sustained support to MAGTF elements when naval surface fires are either unavailable or out of range. During SSC operations, fire support will be provided under restrictive rules of engagement (ROE), often in urban environments, placing a premium on nonlethal and precision fires that limit collateral damage and civilian casualties.

- ***A Concept for Future Military Operations on Urbanized Terrain (MOUT).*** This concept addresses the rapid urbanization that is taking place in the developing world, especially in the littorals. The probability is extremely high that Marines will be called upon to operate in urban areas. Such operations pose major challenges, which the concept addresses by applying the principles of maneuver warfare to an urban environment. The MOUT concept describes a shift from the traditional approach--systematically conducting reconnaissance, isolating the city, securing a foothold in the city, and then clearing the built-up area. This traditional approach is costly both in terms of friendly casualties and its impact on civilian populations. Instead of the traditional approach, the MAGTF will identify enemy centers of gravity and critical vulnerabilities and conduct rapid operations aimed at unhinging the enemy's ability to act. This will require integration of ground and aviation combat power in the city, quickly building and then maintaining an overwhelming operational tempo.

- ***Joint Concept for Nonlethal Weapons.*** This joint concept paper envisions development of nonlethal weapons capabilities for application across the spectrum of military operations. It identifies required operational capabilities that will allow commanders to accomplish assigned missions while simultaneously reducing the adverse effects of military operations, especially collateral damage and civilian casualties. It emphasizes how nonlethal capabilities enhance force protection posture by providing a broad range of alternatives to commanders operating under restrictive ROE. It specifically addresses the potential use of unmanned ground vehicles to employ nonlethal weapons in a MOUT scenario.

  The concept identifies a number of principles that should guide nonlethal weapons development. These principles are well thought out and many, if not all, are just as relevant to the development of UGVs as they are to the development of nonlethal weapons. These principles are synopsized below:

  - Leverage high technology and encourage the pursuit of nontraditional concepts.
  - Enhance the commander's ability to accomplish the mission.
  - Complement and be interoperable with current and planned conventional weapons systems.
  - Create minimal increase in equipment load for both the individual and the unit and in overall lift footprint for the MAGTF.
  - Minimize impacts on the personnel system and MAGTF force structure (i.e., generate as few requirements as possible for new military occupational specialties

(MOSs) or new organizations dedicated to the operation or maintenance of nonlethal weapons systems).
- Design for ease of use after brief individual and unit-level training.
- Design for ease of maintenance with no requirement for system-specific test and repair equipment.

- ***Anti-Armor Operations*.** The anti-armor concept assumes that naval expeditionary forces will encounter adversaries equipped with armored vehicles, main battle tanks, infantry fighting vehicles, or armored personnel carriers in future conflicts. The concept describes how the MAGTF will counter hostile armored forces in the execution of OMFTS in the littorals of the world. Marine armor is not the primary anti-armor weapon, but is rather one component of the MAGTF combined arms team. The MAGTF will counter the armored threat by massed, surprise fires from organic direct and indirect systems supported by naval surface and aviation fires. Enemy armor will be handled "in stride" without employing specialized counter-mechanized attack plans or specialized anti-armor organizations. All MAGTF ground elements will carry numerous organic multipurpose weapons effective against enemy armor. This will include providing the individual Marine with an accurate, lethal, easy to carry, simple to operate, anti-armor weapon. The concept states that Marines are most likely to encounter enemy armor in close, broken, or urbanized terrain providing advantages to dismounted infantry. While such terrain offers cover and concealment, it detracts from armor's ability to maneuver and exploit its stand-off, direct-fire capability. The concept envisions Marines at the small-unit level employing very small sensors that can be maneuvered down streets to look around corners and into buildings to provide real-time information to the tactical commander. In urban warfare, to minimize injuries to noncombatants and collateral damage, nonlethal weapons may be employed to counter enemy armored vehicles. Unmanned ground vehicles are explicitly mentioned in the concept in the context of reconnaissance and target acquisition.

- ***Information Operations (IO).*** IO involves actions taken to adversely affect adversary information and information systems while defending our own. The concept for IO addresses the coordination and facilitation of the warfighting functions of command and control, fires, maneuver, logistics, intelligence, and force protection in the execution of OMFTS. It describes IO that are both offensive and defensive in nature. MAGTFs will conduct offensive IO to deny or disrupt the adversary's use of information and information systems. The MAGTF commander may utilize offensive IO in the form of electronic attack, physical destruction, psychological operations, and/or deception to destroy or degrade the enemy's capability to exercise command and control of military operations. The MAGTF commander will employ defensive IO in the form of information assurance, physical security, operations security, counter-deception, counter-psychological operations, counterintelligence, electronic warfare, and special information operations to protect and defend MAGTF information and information systems. The IO concept highlights the need for:

- Development of doctrine coordinating the various components of offensive and defensive IO and integrating IO doctrine into overall OMFTS doctrine
- New organizational structures that will facilitate the conduct of IO
- Realistic, challenging training.

- ***Mine Countermeasures (MCM).*** This concept recognizes the inadequacy of current naval MCM capabilities and presents a framework for improving those capabilities. The successful implementation of the STOM concept is totally dependent on such improvements. STOM presents significant challenges for mine countermeasures operations. STOM operations depend on achieving tactical surprise. The requirement for tactical surprise precludes lengthy pre-assault MCM operations. The goal is to support rapid maneuver by the landing force at sea, as well as on land. Surface assault elements may be required to conduct mine and obstacle breaching from deep water, through shallow water, very shallow water, the surf zone, and on to inland objectives. The surface assault cannot be constrained by a requirement to attack along prescribed lanes. All elements of the landing force must possess the freedom of action to maneuver at will, both at sea and on the land, either avoiding mines and obstacles or conducting very rapid in-stride breaching operations. Naval MCM capabilities must enable mine detection, classification, identification, avoidance, and, when necessary, neutralization.

- ***Seabased Logistics.*** Next to MCM, perhaps the single most challenging supporting concept to implement is that of seabased logistics. This concept envisions sustaining operating forces ashore directly from a base at sea. Seabased logistics does not mean that ground units will not carry unit-level supplies. However, it does mean that most landing-force-level logistics, including supply dumps and repair facilities, will remain afloat. With seabasing, STOM can be executed without the traditional buildup phase within the beachhead. The logistics tail of landing forces will be smaller, and landing forces will have greater operational freedom of action resulting in increased operating tempo, reduced requirements for rear area security, and enhanced force protection posture. The reduced support infrastructure ashore will also facilitate the rapid redeployment of the landing force.

2.2 Interviews. Over the course of the study the study team gained information from a number of meetings and interviews.

- **Kickoff Meeting, 18 December 2000.** Mr. Bob Kiah, study team program manager; Mr. Charles Preston, study team leader; and Mr. Mark Schon, study team senior analyst, met with the Contracting Officer's Representative (COR), Major Dan McGuire; Mr. Steve Ouimette and Mr. Mike Byerley from NSWC Carderock MC Vehicles Branch; and Major Tim Maxwell, Studies and Analysis Division Technical Study Project Officer (TSPO). Mr. Preston briefed the Government on the technical proposal for the study. The Government approved the proposal as presented. Major Maxwell cautioned the study team on the difficulty of conducting a multiattribute utility analysis.

- **Requirements Division, MCCDC, 11 January 2001.** Mr. Robert Parks, MCCDC UGV Requirements Officer, briefed Mr. Preston and Mr. Schon on the ongoing Marine Corps UGV requirement definition effort.

- **UGV/S JPO, 23-24 January 2001.** Mr. Larry Hennebeck of the JPO briefed Mr. Schon and Mr. Preston on ongoing UGV programs. Mr. Schon and Mr. Preston viewed Gladiator and prototype urban robot demonstrations. The JPO provided training on use of the JPO requirements/technology database as well as an electronic copy of the database.

- **Marine Corps Warfighting Laboratory (MCWL), 2 February 2001.** Captain Thayer of the MCWL briefed Mr. Schon and Mr. Preston on MCWL concept exploration and requirements definition efforts involving the use of UGVs to improve tactical reconnaissance, surveillance, and target acquisition (RSTA) capabilities at battalion and below. Captain Thayer provided a copy of the draft universal needs statement under development by MCWL for a small-unit RSTA capability.

- **Studies and Analysis Division, MCCDC, 5 February 2001.** Mr. Preston met with Studies and Analysis Division TSPOs, Captain Lepson and Major Maxwell, to discuss a methodology for prioritizing NOEs. Mr. Preston described a prioritization scheme involving a multiattribute utility analysis using the AHP process. Major Maxwell and Captain Lepson concurred with the scheme, and Major Maxwell provided Mr. Preston, via e-mail attachment, with a spreadsheet package that could be used to conduct the prioritization process.

- **Center for Emerging Threats and Opportunities (CETO), 5 February 2001.** Gary Anderson, Director of the CETO, briefed Mr. Preston and Mr. Schon on CETO concept exploration efforts that are looking at UGVs supporting Marine Corps RSTA requirements in urban operations.

- **In-Progress Review (IPR) 1, 19 March 2001.** Mr. Kiah and Mr. Preston met with the Study Advisory Committee (SAC) comprising Major Dan McGuire, study COR; Mr. Steve Ouimette and Mr. Mike Byerley from NSWC Carderock MC Vehicles Branch; Major Tim Maxwell, TSPO; and Mr. Robert Parks from Materiel Requirements Division, MCCDC. Mr. Preston briefed the SAC on study progress including the results of the literature search and interviews, the updated threat, the updated documented deficiencies, the updated undocumented deficiencies, the updated technological opportunities, and the updated NOEs. Mr. Preston also briefed the plan for developing TOEs by prioritizing NOEs and converting top-ranking TOEs into COEs. Mr. Preston wrapped up the IPR with a brief discussion of the content and format of the draft final report.

- **Prioritization Seminar Preparation, 16 April 2001.** Mr. Preston met with Captain Lepson to set up the MCCDC Group System Room for the UGV prioritization seminar.

- **Prioritization Seminar, 18 April 2001.** Captain Lepson and Mr. Preston ran the UGV prioritization seminar. Ten company and field grade officers representing a range of combat, combat support, and combat service support MOSs participated. All were from MCCDC (see Appendix F).

3. REPORT REVISION

3.1 Threat. The potential threats to MAGTFs operating in the near to mid term are described in the *Marine Corps Intelligence Activity Mid-Range Threat Estimate 1997-2007* dated August 1997. Marine Corps forces must be prepared to deploy worldwide to deter aggression and, if necessary, defeat threat forces that will range from light infantry insurgent forces to conventional mechanized/armored formations supported by artillery and air. The overall threat to our Armed Forces is presented in various military policy and strategy documents as well as in intelligence studies. These documents agree that we are not confronted by a "peer competitor" and that such a peer competitor is unlikely to emerge in the near future. However, regional conflict as outgrowth of ethnic unrest seems endemic and is particularly difficult to resolve. Furthermore, the proliferation of WMD, along with the means of delivery, is a major concern. The very real threat of WMD employment makes any involvement in regional conflicts risky in terms of our ability to maintain an adequate force protection posture. A common theme running through most current threat assessments is the idea of a state or nonstate actor employing "asymmetric" means to circumvent our military power. Such means are unconventional approaches that exploit our critical vulnerabilities in ways that preclude retaliation in kind. The National Military Strategy mentions three areas of special concern: terrorism, the use or threatened use of WMD, and information warfare. The National Military Strategy states that "We must increase our capabilities to counter these threats and adapt our military doctrine, training, and equipment to ensure a rapid and effective joint and interagency response." This guidance, as discussed below, is directly relevant to the employment of UGVs.

3.1.1 Threat To Be Countered by UGVs. UGVs offer a means of countering many threats that the MAGTF will face in future conflict. Perhaps the greatest payoff from the employment of UGVs against the threat is the resulting improvement in the force protection posture of the MAGTF. For example, UGVs offer the capability to perform particularly hazardous tasks, such as mine clearing under fire, in relative safety. Another example is the use of UGVs in an urban environment where the MAGTF is operating under strict ROE. The performance of tasks, such as crowd control, in this environment is extremely dangerous for Marines. UGVs mounting nonlethal weapons would offer the MAGTF commander the ability to tailor a flexible response, under the ROE in force, with minimal risk to his Marines. Lacking such a capability, the MAGTF commander could be faced with the unpalatable choice of either not attempting the mission or executing the mission, but at a high degree of risk to over-the-horizon Marines and noncombatants. UGVs can be employed to seal off an area from infiltration by enemy reinforcement. UGVs can also be used to counter asymmetric threats: examples range from the neutralization of explosive devices planted by terrorists to the use of UGVs in a major theater war for NBC reconnaissance.

3.1.2 Threat to the UGV. The UGV system will be exposed to the threat of physical destruction as well as the threat of neutralization through enemy information warfare. The nature and level of threat is scenario dependent and will vary depending upon the sophistication of the adversary. Physical threats that can damage or destroy the UGV include both indirect- and direct-fire weapons and mines. Direct-fire threats may include directed-energy weapons targeting the UGV sensors. The enemy can also neutralize or degrade the UGV capabilities through clever use of camouflage, concealment, and deception or through electronic warfare. The UGV signature makes it vulnerable to detection by enemy electronic warfare systems, and UGV data communications links are vulnerable to jamming, disruption, and/or exploitation. Specific UGV system vulnerabilities will depend upon the amount of hardening incorporated into UGV system design. While there is no threat directly targeted against UGVs at the present time, if significant numbers of UGVs are fielded in the future, enemy countermeasures will be forthcoming.

3.2 Documented Deficiencies. The study team updated the documented deficiencies contained in the original report based on an analysis of the *Marine Corps Master Plan for the 21st Century* and an analysis of MAA capabilities. The study team reviewed each of the 36 required operational and support capabilities identified in the Master Plan and each of the 31 MAA capabilities to determine which of these capabilities document deficiencies that could potentially be satisfied by UGVs.

3.2.1 Marine Corps Master Plan. Of the 36 capabilities in the Master Plan (see Appendix D for a complete list of the operational and support capabilities identified in the Master Plan), eleven describe capabilities that might, at least in part, be attained through the employment of UGVs. These capabilities are listed below. The number of the capability is the number assigned in the Master Plan for identification purposes and has no bearing on relative importance or priority.

- R.2. The detection, recording, marking, and clearing of lanes from deep- through shallow-water mined areas.

- R.3. An enhanced information warfare capability.

    - Develop technologies for offensive and defensive information warfare.
    - Continue to improve ground electronic warfare capabilities in electronic attack, electronic support, and electronic protection.

- R.5. Nonlethal capabilities to support military operations.

    - Develop, as the executive agent and in conjunction with the other Services and agencies, nonlethal policies, procedures, technologies, and systems.

- R.8. Reliable, secure, and fully integrated communications capabilities to support over-the-horizon information exchange requirements.

- Develop, in conjunction with the Joint Staff and other Service staffs, command, control, communication, computer, and information systems with sufficient capacity to support operations from the seabase.
- Ensure that the Marine Corps over-the-horizon communication capability is interoperable with naval and joint communication/internet protocols.
- Maintain reliable and secure communications during all phases of operations.

- R.10. Robust operational and tactical intelligence, reconnaissance, surveillance, and target acquisition capabilities.

  - Enhance access to national and theater platforms, intelligence centers, and databases.
  - Acquire, operate, and control tactical intelligence, reconnaissance, surveillance, and target acquisition units and systems.

- R.13. Responsive, accurate, and mobile ground fire support systems.

  - Develop ground indirect-fire systems that support operational requirements.

- R.15. Enhanced capabilities to seize deep objectives from the seabases.

  - Develop fire support, logistics, command and control, and ground and air mobility systems that support ship-to-objective maneuver.

- R.16. The capability to operate effectively at night, in all weather conditions, and on an obscured battlefield.

  - Continue to pursue emerging technology to enhance systems for night and all-weather limited visibility conditions.

- R.17. The capability to record, mark, detect, clear, avoid, and breach mines and obstacles from the high-water mark inland.

  - Develop the equipment and procedures to detect, breach, reduce, clear, record, and mark mines and other obstacles.
  - Develop advanced mobility systems to identify, circumvent, or clear mines while on the move.

- R.18. An enhanced capability to operate in a nuclear, biological, or chemical environment.

  - Enhance organic nuclear, biological, and chemical defense procedures and equipment.
  - Enhance Chemical Biological Incident Response Force capabilities.

- R.25. The capability to provide seabased logistics.

    - Support the development of a concept for seabased logistics that ensures integration with amphibious ships, maritime prepositioned ships, aviation logistics support ships, hospital ships, combat logistics force ships, offshore petroleum discharge systems, and logistics-over-the-shore systems.
    - Develop ship-to-objective logistics distribution systems.
    - Adapt current and evolving combat service support functions to a seabased environment.

3.2.2 Mission Area Analysis. The Studies and Analysis Division of MCCDC has assessed the degree of deficiency existing in MAA capabilities. That list is presented in the table below. Of the capabilities identified, the 17 highlighted could be addressed through employment of UGVs.

Table 1. MAA Capabilities

Degree of Deficiency	Cap. #	MAA Capabilities
1.8%	C1	Deploy Forces to Area of Operations
11.8%	C2	Conduct Maneuver/Maintain Mobility
10.6%	C3	Dominate the Area of Operations
1.2%	C4	Plan and Direct Intelligence Operations
3.7%	C5	Collect Information
1.2%	C6	Produce Intelligence
3.0%	C7	Disseminate Intelligence
3.7%	C8	Plan and Direct Fires
4.0%	C9	Process Targets
10.1%	C10	Attack Targets
0.1%	C11	Plan and Employ C2W
3.6%	C12	Arm--the Capability to Provide Munitions to Weapons Systems
9.4%	C13	Fuel
1.2%	C14	Repair/Maintain Equipment
0.0%	C15	Provide Personnel and Personnel Support
2.0%	C16	Provide Transport Services
3.5%	C17	Supply the Force
1.7%	C18	Perform Engineering Support
0.0%	C19	Provide Health Services
0.0%	C20	Provide General Services
0.0%	C21	Provide Total Asset Visibility
4.3%	C22	Provide Connectivity, Communicate Information
0.8%	C23	Assess Situation
0.0%	C24	Determine and Plan Actions and Operations
4.6%	C25	Direct, Lead, and Synchronize the Forces

3.5%	C26	Enhance Survivability
0.2%	C27	Rescue and Recover
0.9%	C28	Provide Security
0.0%	C29	Conduct Military Law Enforcement
4.1%	C30	Contamination Avoidance
9.0%	C31	Decon, Shelters, Collective Protection

3.3 Undocumented Deficiencies. The study team analyzed each of the current Marine Corps warfighting concepts to identify the improvements needed in MAGTF operational capabilities to implement the concepts. There are a number of operational capability enhancements that must be realized for the Marine Corps to implement the OMFTS concept. The most critical are the improvements in mobility provided through the fielding of the MV-22 and the AAAV and an improved ability to seabase C2, logistics, fire support, and aviation. In addition to these requirements, specific operational capabilities required for successful implementation of OMFTS are listed in the following paragraphs under the supporting concept with which they are associated. Although the format of the warfighting concepts varies, most of these necessary improvements have been extracted from the penultimate section of the concept that addresses required, key, or core capabilities. In addition to reviewing the OMFTS concept, the study team reviewed 11 supporting concepts to identify these required operational capabilities:

- *Ship-to-Objective Maneuver (STOM)*
- *Military Operations on Urbanized Terrain (MOUT)*
- *MPF - 2010 and Beyond (MPF - 2010)*
- *Sustained Operations Ashore (SOA)*
- *Beyond C2*
- *Advanced Expeditionary Fire Support (AEFS)*
- *Joint Concept for Nonlethal Weapons (NLW)*
- *Anti-Armor Operations*
- *Information Operations (IO)*
- *Mine Countermeasures (MCM)*
- *Seabased Logistics.*

The required operational capabilities are listed below under the warfighting concept they support. Many of the operational capabilities identified in these concepts are required for implementation of more than one of the concepts and are, therefore, listed multiple times, usually with a slightly different focus. In the context of this study, these required operational capabilities are considered undocumented operational deficiencies. At the end of this section is a table recapping these by warfighting function: maneuver, fire support, logistics, C2, intelligence, and force protection.

3.3.1 STOM. STOM is the key supporting concept for OMFTS. Full implementation of the STOM concept depends on the fielding of the MV-22 and the AAAV and enhanced ability of the MAGTF to form a seabase. Implementation of STOM requires the following operational capabilities:

Maneuver

- Enhanced mobility. The vertical assault element is severely limited in its ability to rapidly maneuver on the ground following the vertical assault.
- Enhanced scouting and screening capabilities.
- Improved MCM and obstacle breaching capabilities.

Fires

- Improved seabased fire support, both surface fires and aviation.
- Enhanced organic direct-fire capabilities. (The vertical assault force is not accompanied by armor. Consequently, its direct-fire capability is limited to the organic weapons of infantry units.)
- Enhanced fire support including an organic indirect-fire capability capable of maneuvering with the vertical assault element.

Logistics

- Ability to seabase logistics support.
- Improved resupply delivery capability directly from ship to using unit.
- Reduced logistics consumption.
- Mobile supply and maintenance trains accompanying surface assault element.

C2

- Ability to seabase MAGTF C2.
- Improved over-the-horizon (OTH) communications connectivity.
- Shared situational awareness.
- Improved tactical deception capability to enable tactical surprise.

Intelligence

- Enhanced intelligence, reconnaissance, and surveillance capabilities enabling the landing force to use intelligence pull; finding and exploiting gaps.

Force Protection

- Enhanced NBC defense capabilities.

3.3.2 MPF - 2010 and Beyond. The MPF 2010 concept is dependent on improvements in ship design and exploitation of emerging material handling technologies as well as enhancements in seabased storage and maintenance capabilities. Required operational capabilities to implement the MPF 2010 concept include several shipboard applications that could be addressed by mobile robots or UGVs:

Maneuver

- Ability to tactically employ assault support aircraft, surface assault craft, and AAAVs as part of the assault follow-on echelon (AFOE) of an amphibious assault.

Logistics

- Full-spectrum seabased logistics support.
- Improved capability to selectively offload from MPF ships.
- Improved materiel handling.
- Improved seabased storage.
- Improved seabased maintenance.
- Enhanced firefighting and damage control.
- Ability to function as seabased conduit to logistics support from theater or continental United States (CONUS) for indefinite sustainment of MAGTF.
- Improved organic lighterage capabilities.

C2

- Improved communications suite for MPF ships interoperable with MAGTF tactical communications.

Force Protection

- Decreased requirement for shore-based logistics facilities.
- Enhanced seabased medical support.
- Increased seabased billeting.

3.3.3 SOA. Successful implementation of the SOA concept will require a number of improvements in command and control, intelligence, mobility, firepower, logistics, and aviation. These improvements are essential if the MAGTF is to be able to conduct sustained operations from a seabase as envisioned by the concept. Needed capabilities include:

Maneuver

- Sufficient organic tactical mobility for maneuver elements of the MAGTF to gain positional advantage, retain the initiative, and avoid engagements when necessary.
- Both surface and air tactical mobility assets capable of supporting rapid maneuver around the clock, in all weather conditions.

Fires

- Ability to concentrate accurate, lethal and nonlethal fires at the right time and place.

- Improved naval surface fire support capability.
- Responsive, immediately available direct and indirect organic weaponry to support maneuver, exploit opportunities, and provide force protection.

Logistics

- Small, highly mobile, direct-support logistics elements.
- Minimum reliance on shore-based facilities.
- Improved requirements processing and asset visibility.
- Selective throughput and rapid delivery capability.
- Easily emplaced and displaced advanced expeditionary airfields.
- Mobile advanced forward arming and refueling points.

C2

- Distribution of a common operational picture among all elements of the MAGTF, utilizing advanced forward projection and reachback technologies.
- Integration and coordination of the simultaneous actions of numerous maneuver elements.
- Ability to respond rapidly to new opportunities or changes in the situation.
- Ability to coordinate and control external fires in support of maneuver forces ashore.
- Rapid receipt of and response to requests for intelligence, operational, or logistics support.

Intelligence

- Full connectivity from maneuver elements to MAGTF and supporting joint intelligence assets.
- Responsive organic or direct-support capabilities collocated with maneuver elements.

Force Protection

- Improved ability to defend against asymmetric threats.
- Reduced rear area security requirements.

3.3.4 Beyond C2: A Concept for Comprehensive Command and Coordination of the Marine Air-Ground Task Force. Implementation of the Beyond C2 concept requires a number of improvements in the area of C4I. These include the following:

C2

- Increased ability of MAGTF commanders to "reach back" to all elements of national power.
- Improved ability for the MAGTF commander to detect emerging crises, effect deterrent action, respond where necessary, and resolve threats to U.S. interests.

- Robust and reliable communications connectivity from over the horizon to and between rapidly maneuvering units dispersed throughout the battlefield as well as connectivity back to CONUS and the supporting establishment.
- Seabasing of most C2 facilities.

3.3.5 Advanced Expeditionary Fire Support. The fire support system supporting the MAGTF conducting OMFTS operations must be capable of providing flexible and responsive fire support across the entire conflict spectrum. To accomplish this the fire support system supporting the MAGTF must have the following capabilities:

Maneuver

- Improved mobility of ground-based fire support systems, at least equal to the mobility of the maneuver element supported.

Fires

- Flexibility and synergy achieved through a balanced mix of ground-based, naval surface, and aviation fires.
- An integrated fire control system directly linking the sensor acquiring the target to the shooter servicing the target including:
  - Improved target acquisition, location, and identification capabilities
  - Improved target designation capabilities
  - Improved battle damage assessment (BDA) capabilities.
- Ground-based, self-contained fire support system with improved range, accuracy, and lethality.
- Precision point fires and accurate, high-volume area fires.
- Availability of both direct and indirect fires.
- Availability of lethal and nonlethal fires.
- Sufficient range to protect the force and shape the battlefield.
- Responsive all-weather 24-hour support.
- Enhanced naval surface fire support capabilities.
- Improved responsiveness and reduced target engagement time.

Logistics

- Reduced tactical, amphibious, and strategic lift footprint.
- Seabased logistics support.
- Enhanced ammunition handling and resupply capabilities
  - Forward arming and refueling points for ground-based systems
  - Improved packaging
  - Ammunition commonality.
- Reduced logistics support requirements
  - Reduced fuel and ammunition resupply requirements
  - Reduced maintenance burden.

- Capability of operating aviation from expeditionary, shore-based sites when necessary.

C2

- Ability to seabase C2 of fires.
- Improved ability to plan, coordinate, and control fires
  - Streamlined fire support coordination
  - Improved communications connectivity
  - Improved target analysis and selection
  - Near-real-time targeting information
  - Common operational tactical picture and collaborative fire support planning
  - Improved interoperability.

Intelligence

- Improved linkage to national, theater, and tactical reconnaissance, surveillance, and intelligence systems.

Force Protection

- Quick emplacement and rapid displacement.
- Improved operator protection.
- Improved counterbattery capabilities.

3.3.6 A Concept for Future MOUT. In large part, the new concept of urban operations depends on exploiting new technologies. Improved sensing and locating capabilities are needed to reduce the masking effects of built-up terrain. New weapons and ammunition as well as improved target acquisition and fire control are necessary to provide the flexibility to engage enemy forces in urban cover, while simultaneously limiting noncombatant casualties and collateral damage. Mobility enhancements are needed to maneuver in complex, three-dimensional urban terrain that is easy to fortify and barricade. These technology improvements will be keys both to improving the force protection posture of MAGTFs operating in urban areas and to minimizing the adverse impact of urban operations on civilian populations. Specific improvements necessary to implement the MOUT concept include the following:

Maneuver

- Capability to rapidly breach steel-reinforced concrete walls.
- Capability to move vertically inside structures without the use of existing staircases.
- Capability to move vertically on the outside of structures.
- Capability to move horizontally between structures above ground level.
- Capability to penetrate pavement and building foundations to move between surface and sub-surface.

- Ability to employ assault support aircraft for insertion and extraction.

Fires

- Ability to apply measured firepower (lethal to nonlethal).
- Ability to coordinate lethal and nonlethal fires.
- Improved target detection and acquisition.
- Precise fire control and ordnance delivery.
- Ability to call for fire at the very small unit level.

Logistics

- Ability to provide logistics support tailored to MOUT operations.
- Ability to exploit facilities and resources offered by urban environment.

C2

- Improved communications connectivity.
- Improved small-unit navigation and coordination.
- Improved small-unit situational awareness.

Intelligence

- Improved small-unit sensing and locating capabilities.

Force Protection

- Ability to operate safely under restrictive ROE.
- Hardened checkpoints.
- Area denial capabilities.
- Crowd control capabilities.
- Improved body armor.
- Hardened vehicles.

3.3.7 Joint Concept for Nonlethal Weapons. The concept identifies six capabilities that nonlethal weapons should provide to the MAGTF. Some of these capabilities could fit under the fire support category as well as under the force protection category. However, given the emphasis of the concept on the force protection aspect of nonlethal weapons, that is where all of the required capabilities are listed below:

Force Protection

- Capability for crowd control.
- Capability to incapacitate individual personnel.
- Capability to deny personnel access to an area.

- Capability to clear facilities and structures of personnel.
- Capability to deny land areas to vehicles.
- Capability to disable or neutralize specific types of equipment and facilities.

3.3.8 Anti-Armor Operations. The anti-armor concept is based upon improvements in the anti-armor capabilities of the weapons organic to the maneuver elements. Required capabilities to execute the concept include the following:

Fires

- Lethal and nonlethal anti-armor fires organic to the maneuver element.
- Organic ground-based indirect-fire weapons with sufficient responsiveness, mobility, accuracy, sustainability, and lethality against armored targets to provide an all-weather, long-range capability during periods when naval surface and aviation fires are unavailable.
- A family of organic multi-purpose direct-fire weapons, crew served and individual, that will provide accurate, lethal anti-armor fire.

C2

- Near-real-time situational awareness.
- Robust communications networks.
- Timely and accurate battle damage assessment capability.

Intelligence

- Access to sophisticated external reconnaissance, surveillance, and target acquisition capabilities.
- Organic reconnaissance and target acquisition capabilities, such as those provided by locally controlled unmanned aerial and ground vehicles.

Force Protection

- Capability to create effective antiarmor obstacles, including remotely deliverable minefields and nonlethal countermateriel weapons.

3.3.9 IO. The IO concept describes information operations as an integrating concept that enables and enhances the MAGTF commander's ability to effectively command and control friendly forces (defensive IO) and to deny, disrupt, and degrade the adversary's ability to exercise effective command and control of his forces (offensive IO). The concept focuses on the capability improvements needed in doctrine, organization, and training. It does not extensively address necessary capability improvements in materiel. However, of particular interest, with respect to the potential employment of UGVs, is this observation: "...deception can make a significant contribution to force protection by directing an enemy's combat power away from the MAGTF commander's main effort. There is a price, however, since forces and resources must be committed to the deception

effort to make it credible..." From this observation, it is inferred that a requirement exists for a tactical deception capability that can be employed with minimal impact upon MAGTF resources. With this addition, the concept calls for three materiel-related improvements in operational capability:

C2

- Improved security features in C4ISR systems.
- Enhanced reachback capability.

Force Protection

- Easily employed tactical deception capability.

3.3.10 MCM. The MCM concept addresses the single greatest challenge to the ability of the MAGTF to execute OMFTS--the mine warfare threat. This threat precluded significant amphibious operations during Operation Desert Storm. If the mine warfare threat cannot be countered, OMFTS operations cannot be executed without incurring unacceptable risks. Required operational capabilities to implement the MCM concept include the following:

Maneuver

- Capability to deploy autonomous vehicles to neutralize mines using a variety or combination of methods such as influence sweeping or other techniques.
- Capability to maneuver through a mined area using detect and avoid sensors.
- Organic mine and obstacle breaching capability to facilitate rapid maneuver from deep water through the shallow water, surf zone, over the beach, and inland to MAGTF objectives.
- Capability to assure destruction or neutralization of a mine threat in minimum time.

C2

- A C4I network that collects and displays all appropriate intelligence, surveillance, and reconnaissance sensor products and environmental data.

Intelligence

- Early, accurate, and clandestine surveillance and reconnaissance techniques to rapidly and efficiently locate mines and minefields, and identify areas where mines are not present.
- Rapid and wide area detection, classification, and identification of mines, for avoidance, clearance, or breaching.
- Environmentally adaptive sensors capable of overcoming poor signal-to-noise ratio at a significant stand-off distance.

Force Protection

- Rapid clearance of mines with minimal danger to personnel.
- Capability to manipulate unit signature to avoid triggering mines.
- Selected landing craft, amphibious assault craft, and land vehicles provided with the ability to withstand and resist the damage of a close proximity mine detonation.

3.3.11 Seabased Logistics. The concept of seabased logistics underlies the entire concept of OMFTS. The elimination of vulnerable rear area logistics facilities frees the MAGTF commander to focus on the enemy and greatly enhances his force protection posture. However, if the MAGTF is to depend on seabased logistics, a number of improvements are needed in operational capability:

Logistics

- Reduced logistics demand
  - Alternative power sources and energy-efficient, single-fuel systems
  - Better equipment reliability and maintainability characteristics
  - Reduced ammunition consumption through increased use of precision ordnance, improved targeting and BDA, and increased dependence on seabased fires.
- Improved logistics procedures
  - Seabased force closure
  - Selective offload including the capability to transship cargo from containers and distribute ready-for-issue materiel directly from the ship to forces ashore
  - Automated storage and retrieval
  - Improved asset visibility, requisitioning, and rapid distribution
  - Ship-to-objective distribution systems capable of maneuvering and employing deception and firepower to counter threats
  - Reduced inventories ashore
  - Seabased intermediate maintenance capability for MAGTF organic combat equipment
  - Temporary forward arming and refueling points
  - Highly mobile combat service support elements integrated into maneuver element
  - Capability to integrate with theater and strategic logistics to effect seabased replenishment
  - Reconstitution at sea.
- Seabased expeditionary engineering capability to include planning, design, construction, maintenance, and battle damage repair of infrastructure.
- Seabased expeditionary casualty care using rapid stabilization, far-forward surgery, essential care and hospitalization in theater, and rapid evacuation out of theater.

Table 2. Undocumented Operational Deficiencies

Warfighting Function	Operational Deficiency	Concept
Maneuver	1. Enhanced ground mobility for the vertical assault element. 2. Enhanced scouting and screening capabilities. 3. Improved MCM and obstacle breaching capabilities.	**STOM**
	4. Ability for MPF ships to tactically employ assault support aircraft, surface assault craft, and AAAVs as part of the AFOE of an amphibious assault.	**MPF-2010**
	5. Sufficient organic tactical mobility for maneuver elements to gain positional advantage, retain the initiative, and avoid engagements when necessary. 6. Surface and air tactical mobility assets capable of supporting rapid maneuver around the clock, in all weather conditions.	**SOA**
	7. Improved mobility of ground-based fire support systems, at least equal to the mobility of maneuver element supported.	**AEFS**
	8. Capability to rapidly breach steel-reinforced concrete walls. 9. Capability to move vertically inside structures without the use of existing staircases. 10. Capability to move vertically on the outside of structures. 11. Capability to move horizontally between structures above ground level. 12. Capability to penetrate pavement and building foundations to move between surface and sub-surface. 13. Ability to employ assault support aircraft for insertion and extraction.	**MOUT**
	14. Capability to deploy autonomous vehicles to neutralize mines using a variety or combination of methods such as influence sweeping or other techniques. 15. Capability to maneuver through a mined area using detect and avoid sensors. 16. Organic mine and obstacle breaching capability to facilitate rapid maneuver from deep water through the shallow water, surf zone, over the beach, and inland to MAGTF objectives. 17. Capability to assure destruction or neutralization of a mine threat in minimum time.	**MCM**
Fires	1. Improved seabased fire support. 2. Enhanced direct-fire capabilities for vertical assault element. 3. Enhanced indirect-fire capability including system capable of maneuvering with the vertical assault element.	**STOM**
	4. Ability to concentrate accurate, lethal and nonlethal fires at the right time and place. 5. Improved naval surface fire support capability. 6. Responsive, immediately available direct and indirect organic weaponry to support maneuver, exploit opportunities, and provide force protection.	**SOA**
	7. Ability to achieve flexibility and synergy though balanced application of ground-based, naval surface, and aviation fires. 8. Improved, integrated fire control system directly linking the sensor to the shooter including: • Improved target acquisition, location, and identification capabilities • Improved target designation capabilities • Improved BDA capabilities. 9. Enhanced ground-based, self-contained fire support system with improved range, accuracy, and lethality • Precision point fires and accurate, high-volume area fires • Availability of both direct and indirect fires • Availability of lethal and nonlethal fires • Sufficient range to protect the force and shape the battlefield • Responsive all-weather 24-hour support. 10. Enhanced naval surface fire support capabilities. 11. Improved responsiveness and reduced target engagement time.	**AEFS**

	12. Ability to apply measured firepower (lethal to nonlethal). 13. Ability to coordinate lethal and nonlethal fires. 14. Improved target detection and acquisition. 15. Precise fire control and ordnance delivery capabilities. 16. Ability to call for fire at the very small unit level.	**MOUT**
	17. Organic, ground-based indirect-fire weapons to provide an all-weather, long-range anti-armor capability. 18. A family of multi-purpose, direct-fire weapons, both crew served and individual, to provide organic, anti-armor capability for all units.	**ANTI-ARMOR**
Logistics	1. Ability to seabase logistics support. 2. Improved resupply delivery capability directly from ship to using unit. 3. Reduced logistics consumption. 4. Mobile supply and maintenance trains accompanying surface assault element.	**STOM**
	5. Full-spectrum seabased logistics support. 6. Improved capability to selectively offload from MPF ships. 7. Improved materiel handling. 8. Improved seabased storage. 9. Improved seabased maintenance. 10. Enhanced firefighting and damage control. 11. Seabased logistics conduit for support from theater or CONUS for indefinite sustainment capability. 12. Improved organic lighterage capabilities.	**MPF 2010**
	13. Small, highly mobile, direct-support logistics elements. 14. Minimum reliance on shore-based facilities. 15. Improved requirements processing and asset visibility. 16. Selective throughput and rapid delivery capability. 17. Easily emplaced and displaced advanced expeditionary airfields. 18. Mobile advanced forward arming and refueling points.	**SOA**
	19. Reduced tactical, amphibious, and strategic lift footprint. 20. Enhanced ammunition handling and resupply capabilities • Forward arming and refueling points for ground-based systems • Improved packaging • Ammunition commonality. 21. Reduced logistics support requirements • Reduced fuel and ammunition resupply requirements • Reduced maintenance burden. 22. Capability of operating aviation from expeditionary, shore-based sites when necessary.	**AEFS**
	23. Ability to provide logistics support tailored to MOUT operations. 24. Ability to exploit facilities and resources offered by urban environment.	**MOUT**
	25. Reduced logistics demand • Alternative power sources and energy-efficient, single-fuel systems • Better equipment reliability and maintainability characteristics • Reduced ammunition consumption through increased use of precision ordnance, improved targeting and BDA, and increased dependence on seabased fires. 26. Improved logistics procedures • Seabased force closure • Selective offload including the capability to transship cargo from containers and distribute ready-for-issue materiel directly from the ship to forces ashore • Automated storage and retrieval • Improved asset visibility, requisitioning, and rapid distribution • Ship-to-objective distribution systems capable of maneuvering and employing deception and firepower to counter threats • Reduced inventories ashore • Seabased intermediate maintenance capability for MAGTF organic combat equipment	**SEABASED LOG**

	• Temporary forward arming and refueling points • Highly mobile combat service support elements integrated into maneuver element • Capability to integrate with theater and strategic logistics to effect seabased replenishment • Reconstitution at sea. 27. Seabased expeditionary engineering capability to include planning, design, construction, maintenance, and battle damage repair of infrastructure. 28. Seabased expeditionary casualty care using rapid stabilization, far-forward surgery, essential care and hospitalization in theater, and rapid evacuation out of theater.	
C2	1. Ability to seabase MAGTF C2. 2. Improved OTH communications connectivity. 3. Shared situational awareness. 4. Improved tactical deception capability to enable tactical surprise.	**STOM**
	5. Improved communications suite for MPF ships interoperable with MAGTF tactical communications.	**MPF - 2010**
	6. Distribution of a common operational picture among all elements of the MAGTF, utilizing advanced forward projection and reachback technologies. 7. Integration and coordination of the simultaneous actions of numerous maneuver elements. 8. Ability to respond rapidly to new opportunities or changes in the situation. 9. Ability to coordinate and control external fires in support of maneuver forces ashore. 10. Rapid receipt of and response to requests for intelligence, operational, or logistics support.	**SOA**
	11. Increased ability of MAGTF commanders to "reach back" to all elements of national power. 12. Improved ability for the MAGTF commander to detect emerging crises, effect deterrent action, respond where necessary, and resolve threats to U.S. interests. 13. Robust and reliable communications connectivity from over the horizon, throughout the battlefield as well as connectivity back to CONUS. 14. Capability to seabase most MAGTF C2 facilities.	**Beyond C2**
	15. Ability to seabase C2 of fires. 16. Improved ability to plan, coordinate, and control fires • Streamlined fire support coordination • Improved communications connectivity • Improved target analysis and selection • Near-real-time targeting information • Common operational tactical picture and collaborative fire support planning • Improved interoperability.	**AEFS**
	17. Improved communications connectivity. 18. Improved small-unit navigation and coordination. 19. Improved small-unit situational awareness.	**MOUT**
	20. Near-real-time situational awareness. 21. Robust communications networks. 22. Timely and accurate battle damage assessment capability.	**ANTI-ARMOR**
	23. Improved security features in C4ISR systems. 24. Enhanced reachback capability.	**IO**
	25. A C4I network that collects and displays all appropriate SRI and environmental data.	**MCM**
Intelligence	1. Enhanced RSI capabilities enabling the landing force to find and exploit gaps.	**STOM**
	2. Full connectivity from maneuver elements to MAGTF and supporting joint intelligence assets. 3. Responsive organic or direct-support capabilities collocated with maneuver elements.	**SOA**
	4. Improved linkage to national, theater, and tactical reconnaissance, surveillance, and intelligence systems.	**AEFS**
	5. Improved small-unit sensing and locating capabilities.	**MOUT**

	6. Access to sophisticated external reconnaissance, surveillance, and target acquisition capabilities. 7. Organic reconnaissance and target acquisition capabilities, such as those provided by locally controlled unmanned aerial and ground vehicles.	**ANTI-ARMOR**
	8. Early, accurate, and clandestine surveillance and reconnaissance techniques to rapidly and efficiently locate mines and minefields, and identify areas where mines are not present. 9. Rapid and wide area detection, classification, and identification of mines, for avoidance, clearance, or breaching. 10. Environmentally adaptive sensors, capable of overcoming poor signal-to-noise ratio at a significant stand-off distance.	**MCM**
Force Protection	1. Decreased requirement for shore-based logistics facilities. 2. Enhanced seabased medical support. 3. Increased seabased billeting.	**STOM**
	4. Improved ability to defend against asymmetric threats. 5. Reduced rear area security requirements.	**SOA**
	6. Quick emplacement and rapid displacement. **7.** Improved operator protection. 8. Improved counterbattery capabilities.	**AEFS**
	9. Ability to operate safely under restrictive ROE. 10. Hardened checkpoints. 11. Area denial capabilities. 12. Crowd control capabilities. 13. Improved body armor. 14. Hardened vehicles.	**MOUT**
	15. Capability for crowd control. 16. Capability to incapacitate individual personnel. 17. Capability to deny personnel access to an area. 18. Capability to clear facilities and structures of personnel. 19. Capability to deny land areas to vehicles. 20. Capability to disable or neutralize specific types of equipment and facilities.	**NLW**
	21. Capability to create effective antiarmor obstacles, including remotely deliverable minefields and nonlethal countermateriel weapons.	**ANTI-ARMOR**
	22. Easily employed tactical deception capability.	**IO**
	23. Rapid clearance of mines with minimal danger to personnel. 24. Capability to manipulate unit signature to avoid triggering mines. 25. Selected landing craft, amphibious assault craft, and land vehicles provided with the ability to withstand and resist the damage of a close proximity mine detonation.	**MCM**

3.4 Technological Opportunities

3.4.1 Overview. In the nearly ten years since the publication of the UGV Final Report, DoD has expended much effort in the development of UGV technologies as well as in concept demonstration and validation efforts. These efforts are beginning to bear fruit as first generation teleoperated UGVs have been acquired and fielded in support of mine clearing and explosive ordnance disposal (EOD) missions. Most of the research and development efforts have been conducted under the auspices of the DoD JRP, which was established in 1989 in response to congressional guidance to consolidate ongoing robotics programs. Current JPO policy is spelled out in an LOI promulgated on 1 September 2000. This LOI assigns responsibilities to the various JRP managers and supporting agencies. The JRP programs of the most direct interest to the Marine Corps are managed by the

Project Manager, UGV/S JPO. This office is charged with acting as the focal point for developing solutions to Army and Marine Corps requirements.

In addition to and in coordination with the work conducted under the JRP, the Defense Advanced Research Projects Agency (DARPA) is developing and demonstrating advanced robotic technologies under its Tactical Mobile Robotics Program and its Distributed Robotics Program. DARPA is also involved in ongoing JRP programs as well as in supporting Army and Marine Corps technology demonstrations. The Army has the lead role in a number of UGV programs outside of the JRP umbrella that are of interest to the Marine Corps. The following section provides a brief synopsis of ongoing UGV programs of interest to the Marine Corps. JRP programs are covered first, followed by other DoD programs, and lastly a brief listing of some foreign UGV developmental efforts.

3.4.2 JRP Programs

- **Standardized Robotic System (SRS).** Managed by the UGV/S JPO, the SRS program is arguably the most cost-effective development to come out of all of the DoD efforts in unmanned ground systems to date. The SRS is the outgrowth of what began as a Marine Corps small business innovative research (SBIR) initiative. The program has developed a standardized kit to retrofit fielded military vehicles, tracked and wheeled, for teleoperation. The SRS has been installed in turretless M-60 tanks equipped with rollers for mine clearance and employed operationally in Bosnia. Other vehicle applications planned include D7G and T3 bulldozers, the Deployable Universal Combat Earthmover and M9 Armored Combat Earthmover, and a turretless M1 (replacing the M60). The SRS program supports the Army Vehicle Teleoperation ORD, approved on 11 August 1997.

- **Robotic Combat Support System (RCSS).** The RCSS is also managed by the UGV/S JPO. The RCSS is a teleoperated ground vehicle with a 300m line-of-sight range designed for clearing lanes in antipersonnel (AP) minefields and breaching antipersonnel obstacles. The current RCSS program has evolved from several teleoperated mini-flail antipersonnel mine clearing programs including a successful advanced technology demonstration of a mini-flail antipersonnel mine clearing system in Kuwait and an operational mini-flail fielded in Bosnia. The Bosnia experience led to additional requirements incorporated into the Army RCSS ORD, which was approved on 15 February 2000.

- **Gladiator.** The Gladiator Program is managed by the UGV/S JPO. The program is currently based on the joint Army-Marine Corps TUV ORD approved by the Army in August 1995 and by the Marine Corps in May 1996. However, due to changes in warfighting concepts and evolving technologies, both the Army and the Marine Corps are reevaluating the TUV ORD. Based on ongoing concept exploration and validation efforts with prototype systems (two concept validation models have been developed), it is apparent that the current ORD is in need of revision. To address the numerous issues identified during the concept exploration phase, the Marine Corps conducted a

requirement analysis. Based on this analysis, the Marine Corps drafted the Gladiator ORD addressing the scout/surveillance requirements of infantry battalions. The Gladiator ORD will replace the TUV ORD as the basis for the Gladiator Program. The Gladiator is a teleoperated/semiautonomous, small highly mobile UGV with the capability to conduct scout/surveillance missions as well as to carry mission-specific payloads for other warfighting tasks. Planned mission modules will be capable of antipersonnel mine and obstacle breaching, NBC reconnaissance, and direct-fire support, both lethal and nonlethal. Other mission modules under consideration include capabilities for target acquisition/designation, engineer reconnaissance, obscurant delivery, communications relay, tactical deception, and countersniper operations.

- **Man-Portable Robotic Systems (MPRS).** The MPRS Program, also managed by the UGV/S JPO, is focusing on the development of manportable UGVs designed to support urban operations (e.g., building clearing, tunnel and sewer reconnaissance, and under-vehicle inspection) and EOD operations. The program will address the requirements specified in an ORD for a Light Equipment Reconnaissance Set. This ORD is being prepared by the Maneuver Support Center in Fort Leonard Wood, MO, in coordination with the U.S. Army Infantry School, Fort Benning, GA. The system will be designed for modular multi-mission payloads and be able to operate for 4 to 12 hours. The vehicle will have semiautonomous control and navigation. It will be able to detect and neutralize booby traps and antipersonnel mines, detect NBC presence, and deploy smoke. A number of prototype systems have been purchased for concept exploration and validation efforts. These prototypes include the Urban Robot (URBOT) and MATILDA, both teleoperated systems, which have been employed in a number of user experiments and evaluations by the Army.

- **Basic UXO Gathering System (BUGS).** The BUGS program is under the cognizance of the Naval Sea Systems Command, Program Management Office for Explosive Ordnance Disposal (PMS-EOD) (The Navy is the single Service manager for EOD and is responsible for the research and development of EOD systems and equipment.). The BUGS addresses the requirement for an unmanned system to support unexploded ordnance (UXO) detection and neutralization. Currently fielded EOD tools are not adequate to handle the potential dud rate in conjunction with the friendly employment of large numbers of submunitions and scatterable minelaying systems on top of the requirement to clear enemy ordnance. The BUGS concept envisions 20 to 50 small, expendable man-portable robots operating simultaneously. Each robot, or BUG, will autonomously navigate to a target location, avoiding obstacles and other robots along the way, and perform close-in search to acquire the target. Then the robot will either place a countercharge on the target for remote destruction or will pick up the target and deposit it at a common collection point/disposal area and proceed to the next target. An EOD technician could override and control a particular robot if needed. The BUGS program is focused on the development and maturation of enabling technologies with the primary technological emphasis on autonomous control and the enabling system architecture. Two prototype systems are being developed, built, and tested.

- **Remote Ordnance Neutralization System (RONS).** PMS-EOD is responsible for the development and acquisition of the RONS, a joint Service EOD robotic system developed under the JRP. RONS is designed to allow an EOD technician to remotely detect, neutralize, and dispose of UXO and other explosives. The RONS is a fielded system and is being procured by all four Services.

- **Robotics for Agile Combat Support (RACS).** Under the RACS program, the Force Protection Branch of the Air Force Research Laboratory (AFRL) is conducting a number of efforts in robotics research, prototype development, and technology validation. The RACS program is organized into four component programs:

  (1) All-Purpose Robotic Transport System (ARTS). ARTS is a teleoperated robotics platform capable of remotely detecting, analyzing, and clearing explosives and UXO. The ARTS baseline system uses a commercially available tractor with an AFRL-developed, teleoperated control system that enables remote operation up to 5 km line of sight. The ARTS baseline is currently being procured and fielded. Ongoing efforts under ARTS include investigating the integration of a remotely operated laser system for stand-off neutralization capability and the integration of a water-cutting system.

  (2) Advanced Robotics Systems (ARS). The ARS program focuses on the development and integration of unmanned technologies. Ongoing efforts include: Autonomous Vehicle Technologies, focusing on vehicle mobility and control; the Multi-Vehicle Architecture and Control System, developing common architecture designs for advanced robotic systems to support multiple vehicles; Marsupial Control, demonstrating a marsupial control concept between an ARTS and smaller man-portable robotic systems; and High Speed/Large Vehicle Robotics, which is developing the capability to teleoperate a P-19 crash/rescue vehicle and firefighting equipment (This teleoperated system will also provide an unmanned platform for chemical and bacteriological warfare decontamination.).

  (3) Active Range Clearance (ARC). The ARC program focuses on the development of unmanned systems to support and augment EOD personnel in their disposal of unexploded ordnance and removal of residue on Air Force ranges. This includes looking at a number of enabling technologies such as autonomous navigation, multiple system control, and sensor fusion techniques.

  (4) The Next Generation Force Protection Robotic System. This program focuses on the integration of advanced robotic technology into existing platforms as well as development of a new state-of-the-art robotic platform to support force protection missions.

- **Mobile Detection Assessment Response System (MDARS).** MDARS is a robotic physical security system under development by the Product Manager, Physical Security Equipment, Fort Belvoir, VA. The system will consist of multiple interior

and/or exterior mobile platforms controlled from a single console. MDARS will provide the capability to perform intruder detection and assessment, nonlethal response, barrier assessment, and inventory accountability.

- **Joint Architecture for Unmanned Ground Systems (JAUGS).** JAUGS is a JRP technology initiative under the cognizance of the Aviation and Missile Command Research, Development and Engineering Center (AMRDEC). The JAUGS focus is on developing a high-level command and control architecture for UGVs. As defined in the JRP Glossary, "JAUGS is an upper level design for the interfaces within the domain of Unmanned Ground Vehicles." It establishes message and communications standards independent of vehicle platforms and missions. JAUGS uses the Society of Automotive Engineers Generic Open Architecture framework to classify UGV interfaces and complies with the Joint Technical Architecture.

- **Intelligent Mobility Program.** The Intelligent Mobility Program is a JRP technology initiative under the lead of the Tank-Automotive Armaments Command Research, Development, and Engineering Center. The program focuses on improving the mobility of UGVs through the development and demonstration of innovative running gear configurations in combination with intelligent control systems and artificial intelligence. Advanced control and sensor feedback systems will be used to improve traction and trafficability for difficult off-road conditions. Artificial intelligence will help improve the limited mobility of small robotic systems by allowing them to more effectively detect, avoid, and negotiate obstacles. The program will investigate path planning and navigation strategies for both autonomous and semiautonomous operation.

- **UGV Technology Enhancement and Exploitation Program (UGVTEE)/Demo III.** The Army Research Laboratory (ARL) is responsible for the UGVTEE Program including the Demo III Program. The Demo III Program is the primary current focus of the UGVTEE Program. Demo III is a multiyear program designed to develop, assess, and demonstrate new robotic technologies. Demo III includes a series of annual field exercises involving the Army Battle Laboratories to obtain user feedback. The goal of Demo III is the rapid transition of robotics technology to acquisition programs.

3.4.3 Marine Corps. In addition to acting as the proponent for the Gladiator program, the Marine Corps is actively participating in a number of UGV concept evaluation and validation and technology transition efforts.

- **MCWL.** MCWL has employed prototype UGVs in RSTA roles in several experiments and operational assessments and is drafting a universal need statement for a near-term, small-unit RSTA capability based on this experience. Also under the cognizance of MCWL, the CETO is investigating longer-term technology solutions to operational capability shortfalls. A particular area of emphasis is the requirement for urban RSTA capabilities.

- **The UGV Autonomous Operations Future Naval Capabilities Program.** In 1999, the DON S&T Board approved twelve Future Naval Capabilities that represent the highest priority needs of future naval forces. The goal of the Future Naval Capabilities program is to identify technologies that can be transitioned into enabling capabilities. The program includes the capability for autonomous operations, focusing on enhancing the mission capability of Naval Forces by developing technologies that will dramatically increase autonomy, performance, and affordability of unmanned vehicles. In coordination with the JPO UGV/S, the Autonomous Operations Capability is addressing critical technology gaps in the ability to field unmanned ground vehicles in the MAGTF. Technologies identified and developed will be transitioned into the Gladiator program.

- **Wearable Operator Control Unit (OCU).** ONR is also supporting the Marine Corps through sponsoring a SBIR program to develop a comfortable OCU for small teleoperated UGVs that minimizes the burden placed on the system operator. The goal of the program is to develop an OCU that allows the operator to maintain situational awareness and perform other battle tasks while wearing and operating the control system. The proof of concept will be demonstrated by integrating the OCU into the tactical UGV developed by the JPO UGV/S under the Gladiator Program.

3.4.4 Army. The Army plans on making UGVs a major component of the ground combat capabilities that are envisioned in the Army After Next (AAN). While much of the Army effort is directed to larger combat systems that are not compatible with OMFTS, these Army programs and their enabling technologies are of significant interest to the Marine Corps.

- **Future Combat Systems (FCS) Demonstration Program.** The FCS forms the centerpiece of the AAN. The FCS is a multi-mission system of systems comprising highly mobile ground combat platforms incorporating state-of-the-art advanced technologies. The FCS is currently in the early stages of concept exploration. A major component of this concept exploration effort is the FCS Demonstration Program. The FCS Demonstration Program is a collaborative DARPA/Army program to design and demonstrate systems that can implement the FCS concept of a network-centric, distributed force. The first approach to be evaluated includes a manned C2 vehicle/personnel carrier, a robotic direct-fire system, a robotic non-line-of-sight weapon system, and an all-weather robotic sensor system. The Army plans to begin production of FCS in FY 2008 with the first system fielded by 2010.

- **Robotic Follower Advanced Technology Demonstration (ATD).** The Army's Tank-Automotive and Armaments Command (TACOM) and ARL are teaming in the Robotic Follower ATD to demonstrate near-term robotic follower technologies to support the FCS program as well as Objective Force applications.

- **Crew Integration and Automation Testbed (CAT) Advanced Technology Demonstration (ATD).** Under the CAT ATD, TACOM is investigating the crew interfaces, automation, and integration technologies required to operate and support

future combat vehicles. The goal is to develop a single, multi-mission-capable crew station for the FCS program that includes embedded control of both unmanned aerial vehicles (UAVs) and UGVs.

3.4.5 U.S. Special Operations Command (USSOCOM)

- **Special Operations Miniature Robotics Vehicle (SOMROV) Program.** The SOMROV program responds to a USSOCOM ORD. The requirement is for a family of small, light, ground, air, and maritime robotic vehicles geared toward special operations forces requirements. SOMROV platforms will be inserted into an area of operations to gather data and perform other tasks.

3.4.6 DARPA. DARPA is placing a heavy emphasis on the development of advanced robotics concepts. Two programs of particular interest to the Marine Corps are the Tactical Mobile Robotics program and the Distributed Robotics program. The Marine Corps Warfighting Laboratory has used robotic systems originally developed under the Tactical Mobile Robotics program to conduct surveillance missions during urban warfare experiments.

- **Tactical Mobile Robotics Program.** The Tactical Mobile Robotics program is focusing on developing robotic technologies and platforms to support small infantry units and urban warfare. The program envisions the creation of highly effective man-robot teams. In FY 2001, the program will conduct demonstrations of portable robots to determine their operational capabilities for maneuvering in confined spaces (such as in sewers, collapsed buildings, or ventilation ducts), three-dimensional mapping, performing tasks under fire, and climbing up stairs and over obstacles and rough terrain.

- **The Distributed Robotics Program.** Under the Distributed Robotics program, DARPA is developing microrobots that work together in groups in dynamic environments. These small robots will be five centimeters (two inches) or smaller in any single dimension. They will work cooperatively in groups, be capable of different modes of locomotion (land, water, vertical climbing, etc.), and will adapt their behavior based on remote user inputs or onboard sensors.

3.4.7 Foreign Programs. Under the JRP, ARL is designated as the executive agent for international coordination and technology transfer. A number of countries are coordinating with the U.S. in the development of UGV technologies.

- **Canada.** The Army entered a co-funded cooperative engineering development program agreement with the Defence Research Establishment Suffield in Canada. This agreement focused on enhancing UGV situational awareness to improve teleoperation capability. The initial Canadian technology evaluated was the Panospheric Imaging system. The success of this evaluation has led to tentative agreements between the U.S. and Canada for follow-on robotics efforts in the areas of common controller design and improved mobility techniques.

- **France.** The French are investigating military UGV applications under the Systeme Robotise d'Acquisition pour la Neutralisation d'Objectifs program. This program is focused on advanced teleoperation to include a unique multitiered data link design that addresses a major problem in teleoperation--the need for a wideband data link to pass back real-time video to the operator and the line-of-sight limitations normally associated with such wideband data links. The French Ministry of Defense plans include a follow-on program focused on autonomous mobility technology. Through an existing agreement, TARDEC has been collaborating with the French in pursuing the exchange of robotics-related data of possible mutual interest.

- **Germany.** The German UGV program is designated Program Intelligent Mobile Unmanned Systems. This program is addressing autonomous mobility technology. Similar program maturity with a focus on autonomous mobility and shared interest in RSTA applications have resulted in a U.S.-German collaborative research effort focusing on maturing autonomous vehicle navigation technologies to achieve the capability for autonomous cross-country maneuver.

- **Norway.** The UGV/S JPO, under a cooperative R&D initiative, is investigating the integration of a Norwegian flail on a commercial Australian bulldozer for a proof-of-principle technology demonstration. The Norwegian system is currently mounted on a Leopard I chassis, with the gun turret replaced by an overhead weapon station. The system is equipped with a lane-marking capability.

- **UK.** The UK robotics program is based at the Defence Evaluation and Research Agency in Chertsey. Past efforts have focused on teleoperated combat engineering applications and produced about 30 teleoperated robots for use by the Royal Engineers in Kosovo. A new office is focused on autonomous UGV technologies. The UK is interested in leveraging U.S. Demo III technology and in return has offered to focus its efforts on niche technologies that would fill U.S. technology gaps. Specific UK technologies of interest to the U.S. remain to be determined. However, two possible technologies include ongoing UK efforts in ultra-wideband radar and a concept for a small tethered UAV integrated onto a UGV.

3.5 NOEs. The overall study objective is to reexamine the potential uses of UGVs in the Marine Corps and to revise the original UGV study report in light of technological advances and changes in Marine Corps operational warfighting concepts. As a key element of this update of the previous report, the study team developed a number of possible concepts for the employment of UGVs. As in the original study, these potential UGV applications are termed "notions of employment." These NOEs briefly describe how a UGV might be used to perform a battlefield task in support of an operational mission. The development of NOEs has not been constrained by cost, technological risk, or operational suitability and supportability issues. The NOEs are based upon supporting the goals and aims of the *Marine Corps Strategy 21*; the required operational capabilities cited in the *Marine Corps Master Plan for the 21st Century* (paragraph 3.2 above); the MAA capabilities (paragraph 3.2 above); and supporting current Marine Corps

warfighting concepts by addressing the required operational capabilities listed in paragraph 3.3 above. The table below contains a brief description of each NOE as well as identification of the operational capabilities supported.

Table 3. NOEs

Master Plan Capabilities Addressed by NOE	MAA Capabilities Addressed by NOE	Undocumented Deficiencies Addressed by NOE	Notions of Employment by Warfighting Function
			MANEUVER
R.10, R.16	C2, C5	2	**1. Point for Infantry.** A small teleoperated vehicle controlled by operator on foot to act as a robotic point for an infantry unit while patrolling or moving to contact. The UGV would provide rapid surveillance and reconnaissance by optical/thermal sensor while permitting the unit, including the teleoperator, to remain outside of effective small arms range.
R.10, R.16	C2, C5	2	**2. Scout for Mounted Forces.** A small teleoperated vehicle tethered to parent vehicle to go forward and turn a corner or move over a terrain feature in advance of the lead manned vehicle. The UGV would provide rapid surveillance and reconnaissance by optical/thermal sensor prior to the mounted unit turning a corner or cresting a hill.
R.15	C2, C5	2	**3. Wingman.** Medium or large UGVs resembling manned AFVs with similar mobility and armament. A tank or armored reconnaissance platoon comprises one manned and several unmanned tanks/scout vehicles, the latter fighting semiautonomously or autonomously (depending on technology) in support of the manned vehicle.
R.2	C2, C26	3, 16, 17	**4. Amphibious MCM.** A miniature or small amphibious semiautonomous UGV designed to covertly detect and, upon command, neutralize or destroy mines on the beach, in the surf zone, and in very shallow water. Able to navigate over seabed, through surf, and on the beach.
R.15, R.17	C2, C26	3, 14, 16, 17	**5. Obstacle Breaching in the Assault.** A large, teleoperated, amphibious UGV designed to employ the three shot line charge as well as mine plows, flails, and rollers. The UGV would be used by the surface assault element to conduct an in-stride breach neutralizing mines, berms, wire, or other obstacles.
R.17	C2, C26	16, 17	**6. Anti-Personnel Obstacle and Minefield Breaching.** A small, teleoperated UGV to employ the Anti-Personnel Obstacle Breaching System (APOBS). The UGV would allow lead units to quickly conduct in-stride breaching of obstacles and mines, without exposing Marines to enemy covering fires.
R.15, R.16	C26, C28	1, 5	**7. Flank Security and Rear Guard.** A small UGV devoted to flank security and rear guard for infantry elements. Mounting electro-optics (EO) sensors, the semiautonomous UGV would have cross-country mobility characteristics exceeding those of footmobile infantry. Use of UGVs to conduct this physically demanding task would allow Marines to conserve their strength, maximizing unit readiness for combat. Additionally, this would reduce the risk associated with infantry flanking units or rear guards being cut off from the main body.

R.15	C26	2	**8. Obscurant Dispensing.** A small teleoperated or semiautonomous UGV designed to employ obscurants to screen maneuver and conceal assault elements. The UGV would dispense visual, bi-spectral, multi-spectral, and special-purpose smoke/obscurants with precision anywhere on the battlefield to degrade the enemy's RSTA capabilities and to defeat or reduce the effectiveness of direct-fire weapons.
R.15, R.16	C3	5	**9. Exploitation/Pursuit.** A small or medium, highly mobile UGV designed with sensors to operate under all weather and visibility conditions. Operating either semiautonomously or autonomously, the UGV would aggressively exploit the success of offensive operations by maintaining contact with and pressure on withdrawing enemy forces. The UGV would pursue the enemy by fire (direct fire from UGV-mounted weapons and indirect by call for fire and target designation) and maneuver, to an extent reckless for manned units.
R.15	C3, C28	2	**10. Remote Attack/Ambush.** A small UGV designed for autonomous offensive operations well forward of friendly forces. The UGV would engage enemy units with direct-fire antipersonnel and antiarmor weapons. Could be employed as part of a deception effort or to help seal objectives from enemy counterattacks.
R.15	C26, C28	2	**11. Landing Zone (LZ) Security.** A small UGV inserted to seal off a LZ and provide suppression of targets of all types until L-hour.
R.15	C2, C16, C17	1, 5, 6	**12. Mechanical Mule.** A small, teleoperated or semiautonomous, highly mobile UGV designed to provide transportation of supplies and equipment for small infantry units.
R.15	C2, C18	5	**13. Assault Bridging.** A large teleoperated UGV that provides the capability to conduct assault bridging under fire with minimal risk to operator. Highly mobile and, depending on the situation, accompanies the lead units of the surface maneuver element.
			FIRES
R.15	C10	2, 6, 18	**1. Rifle Squad/Fire Team Base of Fire.** A small, teleoperated UGV to provide direct-fire support to the rifle squad. Weapons package would include antipersonnel, antitank, and antibunker capabilities. Envisioned as a potential replacement for the MG squad and the assault squad of the weapons platoon. Perhaps carried as a crew-served weapon in several packages by operators and then launched in an assault or set in a covering or defensive position. A miniature version might serve as a replacement for the automatic rifleman of the fire team.
R.15	C10	2, 6	**2. Robotic Flamethrower.** Flamethrowers are no longer available in tables of organization (T/Os). This is due primarily to the vulnerability of operators in employing such a short-range weapon. However, the effectiveness of the flamethrower against bunkers, caves, and tunnels is unsurpassed. This NOE envisions a flame weapon mounted on a small, expendable teleoperated UGV. The UGV could be moved by vehicle to the vicinity of the action and the operator would maneuver the UGV into firing range from a covered position.
R.15	C10	2, 6, 18	**3. Infantry Battalion Direct-Fire Support.** A small, teleoperated or semiautonomous UGV, employed by the weapons company of the infantry battalion, that would engage the enemy's outposts and screens with direct fires to suppress or fix enemy units. This would free manned maneuver units to carry out their assigned tasks and preserve the momentum of the main body. If a hasty assault becomes necessary, UGVs could provide a base of fire for the assault or move in coordination with assault elements of the battalion to clear and force through enemy and to rapidly exploit success.
R.5, R.15	C10	2,6,12	**4. Assault on Fortified Positions.** A small, short-range UGV employed to destroy or neutralize fortified positions through either lethal or nonlethal means depending upon the situation. Employing chemical agents, breaching munitions, and/or advanced lethal and nonlethal technologies, the UGV would operate in tandem with assault teams.
R.10, R.13, R.16	C8	3, 8, 9, 11, 14, 15	**5. Robotic Forward Observer/Target Designator.** A small or miniature UGV, inserted by surface or air, forward of maneuver elements or defensive positions. Onboard sensor package designed to operate in all weather and visibility conditions. The UGV would acquire and identify targets, determine target location, designate targets or adjust fire, and conduct BDA.
R.13, R.15	C3, C10	2, 4, 6, 9, 17	**6. Fire Support System.** A family of small to medium UGVs with containerized munitions loads. Capable of reinforcing manned systems (perhaps as wingman system), or operating remotely to provide fires of all types. An expendable version of the system could operate semiautonomously in enemy rear, perhaps coordinating with surveillance and RSTA UGVs, firing upon designated targets to disrupt and harass enemy activities.

LOGISTICS			
R.25	C28	2, 26	**1. Convoy Escort.** A small or medium UGV designed to protect logistics convoys from enemy action. A small armed-escort UGV could be towed on a standard towing pintle of a cargo vehicle (or several UGVs could be carried in a trailer). Uses the prime mover's power to keep batteries topped off. Equipped with multipurpose direct-fire weapons, in the event of enemy action it would employed to search for, acquire, and neutralize enemy forces. A larger UGV with a similar sensor and armament package could precede the convoy to detect the enemy and prevent the ambush of the main body.
R.25	C16, C17	2, 26	**2. Resupply.** A medium to large UGV designed to follow a manned vehicle in trace, duplicating movements and automatically offloading cargo upon remote or direct command.
R.15, R.25	C16, C17	2, 16, 26	**3. Amphibious Train and Resupply.** A large amphibious UGV designed to carry supplies and equipment directly from the ship to the surface assault element ashore. Capable of operating in coordination with manned vehicles or as part of a completely unmanned convoy. Also capable of following closely in trace of the surface assault element as a logistics train.
R.25	C17	2, 4, 7, 13, 14, 16, 18, 20, 26	**4. Materiel Handling Equipment.** UGV/robot designed to operate with logistics trains, resupply convoys, or forward arming and refueling points to load or offload cargo semiautonomously.
R.15	C12	4, 20, 26	**5. Artillery Resupply.** A small to medium (not including the weight of the load transported) UGV designed to follow a firing unit carrying ammunition. Capable of autonomous unloading of resupply vehicles and loading of firing units.
R.25	C20, C26	10	**6. Firefighting.** A small UGV designed primarily to support firefighting requirements associated with airfields, but applicable to fuel and ammunition dumps and other rear area requirements. A variant could be used to support shipboard firefighting.
C2			
R.8	C22	2, 13, 17, 21	**1. Communications Relay.** Miniature UGVs designed to support communications links for MAGTF C4I architecture including UGV command and data links. Multiple UGVs could maneuver or be maneuvered as necessary serving as communications relays to maintain connectivity beyond line of sight.
R.10, R.15	C5	1, 6, 16, 25	**2. Air Defense Radar.** A small UGV designed for employment early in a STOM to extend the radar coverage of the ATF and fill gaps in that coverage. Depending upon the situation, the UGV might be inserted by air as part of advance force operations.
INTELLIGENCE			
R.10	C5	1, 7, 8	**1. Amphibious Reconnaissance.** Small amphibious autonomous UGV of highly covert nature deployed by air, surface, or subsurface means. Able to navigate over seabed, through surf, and on the beach. Replaces/augments SEALs and force reconnaissance in conducting beach reconnaissance and hydrographic surveys. Reports periodically by burst transmission.
R.10, R.15	C5	1, 5, 7	**2. Route Reconnaissance.** A small semiautonomous UGV employed well in advance of the maneuver element to determine trafficability and to detect mines, obstacles, and enemy units along potential avenues of advance. Input from the UGV sensors would allow the maneuver element to make in-stride adjustments to their scheme of maneuver to avoid enemy strengths and to take advantage of enemy weaknesses. The UGV would be employed in concert with manned or unmanned aircraft to relay commands to the UGV and sensor data from the UGV beyond line of sight. Once the enemy is encountered, the system could be utilized to maintain surveillance of enemy forces.
R.10, R.15	C2, C5	1	**3. Deep Reconnaissance.** A small autonomous UGV designed to locate gaps in enemy defenses. The UGV with a full array of EO and electronic sensors would roam the battlefield and provide real-time information to maneuver element commanders. When a gap is located after relaying the information, the UGV would continue to provide surveillance until the gap is exploited or eliminated from consideration.

R.10, R.15	C5	1	**4. Surveillance.** An autonomous UGV, micro or miniature with limited mobility and inserted by air, to provide long-term surveillance of areas of interest. Through EO/IR, synthetic aperture radar/moving target indicator, signals intelligence, communications intelligence, and other emerging sensor capabilities, the UGV will allow continuous monitoring of an area of interest. After the initial vertical and surface assaults the UGV would provide early warning of counterattacks and support their engagement with direct and indirect fires.
R.10, R.15	C5, C28	1, 5, 7	**5. Close Reconnaissance.** A small teleoperated short-range UGV with an austere sensor suite and employed at the infantry battalion level to probe suspected enemy positions. The UGV would minimize the risk of unexpected enemy contact and defeat enemy deception efforts. By employing the UGV in reconnaissance-pull tactics, the commander can avoid enemy strong points and preserve freedom of action.
R.16	C5, C28	1, 3, 5, 7	**6. Robotic OP/LP.** A small teleoperated UGV positioned forward of manned outposts creating greater depth to the defensive position. Using its EO, acoustic, and seismic sensors, the UGV would transmit warning information to the main force. As enemy forces approach, the UGV could be employed to either designate targets or call for and adjust indirect fires. The UGV could also mount weapons, or be employed in concert with UGVs capable of direct fire, to directly engage and force premature deployment of the enemy.
R.10	C5, C26	3, 5, 7	**7. Urban RSTA.** A small teleoperated UGV designed to support small units operating in an urban environment. The UGV would be employed to detect the presence of enemy forces and non-combatants using EO and acoustic sensors. The UGV could be employed in coordination with manned patrols or in a standalone mode. In combat operations the UGV would be used to acquire, identify, locate, and designate targets permitting precision destruction with minimal collateral damage. The UGV would also conduct rapid battle damage assessment of engagements.
R.10	C5	1	**8. Long-Term Surveillance.** A UGV with a compete set of EO and electronic sensors designed for long-term surveillance of an area. Such UGVs could be used to reduce the manpower requirements involved in enforcing peace agreements. Transmitting information directly to the MAGTF Surveillance and Reconnaissance Center (SARC), the UGV could monitor disputed borders or areas and trigger appropriate MAGTF responses to threat provocations.
R.10	C5, C26	3, 5, 7	**9. Tunnel Reconnaissance and Clearing.** A micro or miniature UGV designed to reconnoiter tunnels, sewers, ventilation ducts, etc. The UGV could also dispense nonlethal incapacitating agents or employ direct-fire weapons to neutralize threats and deny potential avenues of approach to the enemy.
R.10	C11	1	**10. Electronic Warfare.** A UGV designed to be inserted behind enemy lines by air, perhaps via artillery or parafoil, and seek hide positions autonomously, activating on schedule or command to disrupt enemy communications. The UGV could also be designed to search for, identify, collect, and relay electronic signals for exploitation.
R.10	C5, C26	5, 7	**11. Building Reconnaissance and Surveillance.** A micro UGV designed to maneuver within a building to perform reconnaissance and surveillance. Preferably capable of covert operation, the UGV would use EO and audio sensors to assess the situation. If delivered by a projectile, penetrator precursor charges or other techniques might permit use against buildings with boarded-up windows and locked doors or against fortifications. Depending on the situation, larger versions might be designed to forcibly break into and secure buildings, but at the expense of tactical surprise.
R.10	C5	1, 3	**12. Artillery Emplaced Surveillance.** A package of micro UGVs delivered by standard artillery bus or a single miniature UGV incorporated in a specialized container. External designator could guide the artillery projectile carrying the UGVs to the location desired. The UGV would then move to a hide position and use sensors to detect visual, electronic, and other emissions.
FORCE PROTECTION			
R.15	C26, C28	11,17, 19, 20, 21	**1. Area Denial UGV.** The potential loss of ability to employ AP minefields drives a requirement for UGVs to perform a similar mission. Mobile (limited range and speed, transported for operational deployment), miniature UGVs fitted with sensors and various armament packages would deny enemy entry into an area. Employed semiautonomously and in concert, such vehicles could provide maneuverable and easily removable barriers.

R.18	C26, C30		**2. Nuclear, Biological, and Chemical Reconnaissance.** A small UGV to serve as an NBC reconnaissance vehicle for maneuver elements. It would have the capability to employ chemical and biological agent detection systems and to map contaminated areas. The UGV would detect and/or classify the type and level of chemical or biological contamination in advance of Marine units. This information would then be relayed to unit NBC control centers. This would allow maneuver elements to decide whether to avoid the contaminated area or to take appropriate protective measures to move through the area of contamination.
R.3, R.15	C26	22	**3. Operational and Tactical Deception.** A family of UGVs of various sizes with the capability to emit false visual, thermal, acoustic, and electromagnetic signatures to confuse and mislead the enemy. Employed at both the MAGTF and maneuver element levels, such UGVs could be used to support large-scale, operational deceptions or local tactical deceptions. Employed either autonomously or in conjunction with manned units to mislead the enemy as to the strength, disposition, and actions of friendly forces.
R.10, R.16	C26, C28	11	**4. Covering Force.** A small UGV designed to operate either in coordination with manned elements of a covering force or employed cooperatively with numerous other UGVs as an unmanned covering force. Use of UGVs enables the MAGTF commander to extend security areas far forward to inflict maximum damage and disruption on attacking enemy forces. The UGVs would be fitted with EO and electronic sensors and target designation devices as well as direct-fire weapons. The UGVs could provide early warning of the enemy advance, engaging the enemy in order to damage, delay, disrupt, and deceive as to the true location of the main battle area. As the enemy closes, the UGVs would maintain contact while falling back under pressure.
R.10, R.16	C26, C28	11	**5. Combat Patrolling.** A small UGV with EO sensor package to move throughout the area of interest detecting enemy units, activities, and obtaining terrain information and relaying this information to unit commanders. Sectors that appear to be the most probable for enemy contact would be assigned to UGV patrols, thereby minimizing risk to individual Marines. Would be a useful economy-of-force measure for rear area security operations.
R.10, R.16	C26, C28	4, 11	**6. Robotic Bunker.** A family of small to medium expendable UGVs designed to provide unmanned strongpoints as part of a barrier or as a standalone defensive position covering key terrain. Equipped with a variety of direct-fire weapons as well as a target acquisition and designation package, the UGV would defend in place inflicting maximum damage on attacking forces. Such UGVs could be employed to achieve economy of force in offensive operations or to allow manned forces to more safely disengage during a retrograde movement or a withdrawal. Smaller versions could serve as automated roadblocks and checkpoints.
R.10, R.16	C26, C28	11	**7. Stay-Behind Force.** A family of micro through small, semiautonomous or fully autonomous UGVs of limited mobility designed to conduct stay-behind operations. UGVs would be carefully positioned by withdrawing forces to remain undetected in the security area. Tasks performed would include all-weather reconnaissance, surveillance, and target acquisition, identification, location, and designation as well as BDA. Operating in concert with area denial UGVs and with the entire range of fire support systems available to the MAGTF, these UGVs could destroy or disrupt attacking forces and deny key terrain to the enemy over an indefinite period.
R.5	C26, C28	4, 9, 10, 11, 12, 15, 16, 17, 18	**8. Urban Warrior.** A small teleoperated UGV designed to support MOUT operations. The UGV would close with and disarm or neutralize a sniper, gunman, or hostage holder with minimum risk to noncombatants and Marines. The UGV would also be used, with either nonlethal or lethal payloads depending on the situation and the ROE, for crowd control and area denial operations. Use of the UGV would allow precision delivery of riot-control and incapacitation agents.
R.5	C5, C26	4, 9, 18	**9. Building Reconnaissance and Clearance.** A UGV designed to be employed inside buildings to determine the tactical situation. If the sensors locate threats, the system could employ nonlethal incapacitating agents to clear the building.
R.10	C26, C28	4, 5	**10. Countersniper.** A small UGV designed to rapidly detect, locate, and neutralize snipers.

R.10	C26, C28, C29	5, 9, 10, 11, 17	**11. Automated Sentry.** A small UGV for semiautonomous patrolling of defensive positions and rear area facilities. These UGVs could be employed by rear area operations center to provide security for POL farms, ammunition dumps, airfields, and other high-value assets. Employing visual, thermal, and acoustic sensors the UGV would maintain mobile surveillance of an area or stationary surveillance at a checkpoint. A loudspeaker could interrogate anyone approaching the area and appropriate action could be initiated when required.
R.10, R.25	C26, C28, C29	8, 24	**12. Interior Guard.** Miniature or small UGV designed to provide surveillance on board a ship or inside a building or warehouse. Employing visual, thermal, and acoustic sensors the UGV would maintain autonomous surveillance of the facility notifying a rear area security center of intrusion. The UGV could periodically inventory high-value items.
	C26	4	**13. Bomb Detection/Disposal.** A small UGV capable of remotely detecting, classifying, and neutralizing unexploded ordnance and explosive devices. Eliminates need for EOD Marines to approach/handle such devices.
	C18, C26	6	**14. Teleoperated Engineer Vehicles.** A family of teleoperated UGVs of various sizes employed to dig fighting positions for troops, crew-served weapons, and vehicles. UGV designed to support rapid preparation of fighting and firing positions under fire. UGVs could also conduct other hazardous engineer operations (such as obstacle removal, rubble clearing, and rapid runway repair) under the threat of snipers or unexploded ordnance with minimum risk to the operator.
R.23	C27	1, 2	**15. Casualty and Equipment Recovery.** A UGV designed to serve as an unmanned ambulance or recovery vehicle returning casualties to a designated collection point. Ambulance variant could be amphibious to return casualties to seabased treatment facilities.
R.18	C31	4	**16. Remote Decontamination.** A small or medium UGV designed to perform hasty decontamination of vehicles and personnel. The UGV would apply sprays to vehicles and equipment permitting vehicle crews and mounted troops to safely dismount and recover from NBC attack or exposure. The UGV could also be used to decontaminate aircraft and rear area facilities.

3.6 TOEs (Prioritized NOEs). In the original study, NOEs were prioritized through a multiattribute utility process using a modified Delphi technique to weight attributes of each NOE and then to score NOEs with respect to each attribute. The highest-ranking NOEs were termed TOEs and, after being validated through a seminar wargame, were developed into COEs. In this update the study team employed a similar multiattribute utility approach to rank NOEs. However, the AHP was used to determine weights for attributes and no attempt was made to force group consensus when weighting attributes and scoring NOEs. On 18 April Captain Lepson and the study leader, Mr. Preston, ran a prioritization seminar with ten Marine officers participating (see Appendix F for a more detailed description of the prioritization effort). The TOE rankings based on the results of the seminar are presented in Table 4 below.

Table 4. TOEs

Rank	TOE (Prioritized NOE)	NOE ID #
1.	Communications Relay	C1
2.	Nuclear, Biological, and Chemical Reconnaissance	FP2
3.	Anti-Personnel Obstacle and Minefield Breaching	M6
4.	Point for Infantry	M1
5.	Building Reconnaissance and Clearance	FP9
6.	Robotic Forward Observer/Target Designator	F5
7.	Close Reconnaissance	I5
8.	Bomb Detection/Disposal	FP13

9.	Route Reconnaissance	I2
10.	Rifle Squad/Fire Team Base of Fire	F1
11.	Electronic Warfare	I10
12.	Assault on Fortified Positions	F4
13.	Combat Patrolling	FP5
14.	Urban RSTA	I7
15.	Urban Warrior	FP8
16.	Amphibious Reconnaissance	I1
17.	Amphibious Train and Resupply	L3
18.	Amphibious MCM	M4
19.	Scout for Mounted Forces	M2
20.	Surveillance	I4
21.	Countersniper	FP10
22.	Obstacle Breaching in the Assault	M5
23.	Resupply	L2
24.	Remote Decontamination	FP16
25.	Robotic OP/LP	I6
26.	Building Reconnaissance and Surveillance	I11
27.	Flank Security and Rear Guard	M7
28.	Infantry Battalion Direct-Fire Support	F3
29.	Artillery Resupply	L5
30.	Deep Reconnaissance	I3
31.	Air Defense Radar	C2
32.	Tunnel Reconnaissance and Clearing	I9
33.	Materiel Handling Equipment	L4
34.	Landing Zone Security	M11
35.	Teleoperated Engineer Vehicles	FP14
36.	Convoy Escort	L1
37.	Casualty and Equipment Recovery	FP15
38.	Fire Support System	F6
39.	Interior Guard	FP12
40.	Automated Sentry	FP11
41.	Area Denial UGV	PF1
42.	Obscurant Dispensing	M8
43.	Wingman	M3
44.	Exploitation/Pursuit	M9
45.	Covering Force	FP4
46.	Robotic Flamethrower	F2
47.	Remote Attack/Ambush	M10
48.	Operational and Tactical Deception	FP3
49.	Long-Term Surveillance	I8
50.	Firefighting	L6
51.	Assault Bridging	M13
52.	Mechanical Mule	M12
53.	Robotic Bunker	FP6

54.	Artillery Emplaced Surveillance	I12
55.	Stay-Behind Force	FP7

3.7 COEs. In the original study, a seminar wargame was used to eliminate impractical NOEs and to determine which TOEs offered the most potential. Based on the wargaming, nine COEs were "validated." In this update wargaming was not used to validate COEs. Instead, the 15 top-ranking TOEs (rank-ordered NOEs) were selected for refinement into the 13 COEs described in the paragraphs below. The COEs are fairly narrowly focused on the warfighting tasks to be performed, and TOEs are grouped together sparingly. While a particular UGV chassis, fitted with an appropriate mission module, might be capable of being used for nearly any purpose, a COE written from this perspective would be too broad to be useful. TOEs have been incorporated into COEs based on how and by whom the UGV will be employed as well as by the nature of the tasks to be performed. In mapping the first 15 TOEs into COEs (see Table 5 below), there are only two instances in which mapping is not one for one. Based on similar operational and organizational profiles, an additional seven lower-ranking TOEs were incorporated into the 13 COEs. In all cases COEs were developed from a functional vice a design perspective. The process of consolidating and refining into COEs removed the rank order assigned to individual NOEs. This study does not assign a rank order or a relative priority to COEs.

Table 5. Incorporation of NOEs into COEs

COE Title	NOE #	NOE Title
Communications Relay	**1**	**Communications Relay**
Nuclear, Biological, and Chemical Reconnaissance	**2**	**Nuclear, Biological, and Chemical Reconnaissance**
Antipersonnel Obstacle and Minefield Breaching	**3**	**Antipersonnel Obstacle and Minefield Breaching**
Point for Infantry	**4 & 7**	**Point for Infantry & Close Reconnaissance**
Building Reconnaissance, Clearance, and Surveillance	**5 & 26**	**Building Reconnaissance and Clearance & Building Reconnaissance and Surveillance**
Robotic Surveillance and Target Acquisition	**6, 20, & 34**	**Robotic Forward Observer/Target Designator; Surveillance; and Landing Zone Security**
Robotic EOD Operations	**8**	**Bomb Detection/Disposal**
Route Reconnaissance	**9**	**Route Reconnaissance**
Small-Unit Base of Fire	**10**	**Rifle Squad/Fire Team Base of Fire**
Remote Electronic Warfare (EW) Operations	**11**	**Electronic Warfare**

Neutralizing Fortified Positions	**12 & 46**	**Assault on Fortified Positions & Robotic Flamethrower**
Combat Patrolling	**13, 45, & 47**	**Combat Patrolling; Covering Force; & Remote Attack/Ambush**
Urban Operations	**14, 15, & 21**	**Urban RSTA; Urban Warrior; & Countersniper**

The COEs focus on organizational and operational considerations. In this regard, the requirement for operational suitability cannot be overemphasized. Several operational suitability goals apply equally to every concept and are synopsized here:

- UGVs must complement and be interoperable with current and planned manned systems.
- UGVs must fit within the amphibious and strategic lift footprint of the MAGTF.
- UGVs must not impair the tactical mobility of supported units.
- UGVs must generate a minimal impact on MAGTF force structure (i.e., no requirements for new MOSs or new organizations dedicated to the operation or maintenance of UGVs).
- UGVs must be compatible with the Marine Corps C4I architecture.
- UGVs must be designed for ease of operation and maintenance in an austere expeditionary environment.

The thirteen COEs below are formatted in three sections:

- A brief overview describing the COE and identifying the TOEs incorporated. The overview highlights existing deficiencies in capability and suggests why the concept will improve the warfighting capability of the MAGTF.
- A brief mission statement describing the mission or operational tasks to be performed including identification of documented and undocumented deficiencies addressed.
- An operational concept describing how, where, when, and by whom the UGV envisioned in the concept will be used.

Communications Relay

- **Overview**

The OMFTS concept exploits the principles of maneuver warfare in the conduct of amphibious operations. This concept offers tremendous payoff and is well designed to meet the demands of expeditionary warfare in the littorals in the 21st Century. However, one of the difficulties in implementing the concept is the limited ability to maintain communications connectivity with the rapidly maneuvering, geographically dispersed maneuver elements of the MAGTF ground combat element (GCE) during ship-to-objective maneuver. For the near term, Marine Corps tactical communications will rely extensively on very high frequency (VHF) and ultra high frequency (UHF) radios that depend on line of sight. Establishment of communications relays helps to overcome these line-of-sight limitations. However, such relays need to be placed on high ground and, given their electromagnetic signature, make highly visible targets for an enemy with even rudimentary EW capabilities. Use of a UGV or group of UGVs allows communications relays to be established in locations where the risk to a manned relay would be untenable. In contrast to UAV platforms, UGVs would offer superior endurance and the ability to operate in all conditions of climate.

The UGV could relay both voice and data traffic using radio frequency (RF) or fiber-optic links depending upon the situation. Multiple UGVs could be used to establish a robust communications network providing complete coverage of an area of operations. Use of UGVs as relays would be particularly significant in the conduct of urban operations. In the city, line of sight is measured in meters vice kilometers. Signal degradation is proportional to the density and height of buildings and other urban terrain features. Additionally, the urban environment may be hindered by electrical and trolley lines, which can create an unfavorable electromagnetic environment contributing to increased interference and degraded signals. This means that it is very difficult to maintain any form of communication with consistency. During MOUT, UGV relays could be employed in teams to establish a communications network providing connectivity during the operation. The TOE that is addressed by this concept is number 1, Communications Relay (C2-1).

- **Mission**

The primary mission of the UGV in this concept is to support the MAGTF GCE in the conduct of OMFTS operations of all types across the entire conflict spectrum. A secondary mission would be to support all elements of the MAGTF during SOA and military operations other than war (MOOTW). The UGV would be employed to extend the range of MAGTF radios and permit the establishment of a robust, redundant, and reliable command and control network throughout the area of operations.

This concept addresses the following documented deficiencies:

R.8 and C22.

This concept addresses the following undocumented deficiencies:

2, 13, 17, and 21.

- **Operational Concept**

The UGV communications relay will be employed as an integral part of the Marine Corps tactical communications network. It will support existing single channel VHF and UHF radios, permitting the automatic retransmission of voice and data traffic throughout the area of operations. Employment planning for MAGTF units will be the responsibility of the G-6/S-6 with assistance from the supporting communications unit/detachment. The employment of the UGV relays will be an integral part of the overall unit communications plan and the tactical communications architecture.

In addition to their use in the establishment of an overarching tactical communications network, UGV communications relays may be dedicated to support a particular task or mission. Such missions might include providing connectivity to manned or unmanned outposts or patrols. MOUT operations in particular would benefit from the availability of UGV communications relays. Such relays might be assigned to an urban patrol in teams, allowing the patrol to maintain connectivity to higher headquarters as well as connectivity to other UGVs performing RSTA tasks in advance of the patrol. The possibilities for employment are virtually unlimited, especially when one factors in the possibility for employment in conjunction with manned or unmanned airborne relays. The UGV relays can increase the survivability of command post (CP) complexes by remoting the RF signature. They would be extremely useful in supporting electronic deceptions.

The operating environment for the UGV communications relay is the operating environment of the MAGTF. The relay will be used in virtually every type of geographic and climatic condition. As mentioned previously, urban areas present a particularly difficult communications environment. Manmade terrain features constructed of a wide variety of materials will limit the line of sight and often cause interference with RF signals. The threat encountered will be as varied as the operating environment, including conventional forces possessing the EW capability to target C2 nodes including radio relays. With the worldwide proliferation of modern technology even relatively unsophisticated third world armies can be expected to possess rudimentary capabilities for electronic location and targeting of communications nodes. It is therefore imperative that communications relays possess at least the same degree of communications security and electronic counter countermeasures (ECCM) capability as the other links in the tactical communications architecture.

The UGV relay will be employed at all levels of the GCE from the division to battalion level. The UGV relay will be employed to establish a tactical communications network

providing assured and seamless (without breaks or pauses at relay points) connectivity for both voice and data transmissions among GCE maneuver elements down to platoon and squad level. The tactical communications network based on UGV relays would allow continuous modification and extension without interruption of service. The flexibility and reliability provided though use of UGV relays is well suited to the needs of small, fast-moving MAGTF units.

During pre-assault phases of amphibious operations, the landing force could place communications relay UGVs in secure locations by covert means to support reconnaissance and surveillance operations of manned and unmanned systems. As the STOM unfolds UGV relays would be employed as necessary to ensure continuous communications coverage for MAGTF maneuver elements. After the STOM and during sustained operations ashore, the communication relay UGVs would serve as antenna farms for CPs, fill in dead spaces in the communications architecture in the area of operations, and provide continued support of deep reconnaissance and surveillance efforts. The UGV relay would be transported by both aircraft and ground tactical vehicles. It might consist of a family of UGVs with smaller variants being manportable and of fairly limited mobility. Larger variants would be transported to the general vicinity of employment by either tactical vehicles or vertical short takeoff and landing (VSTOL) aircraft.

The communications unit or detachment would be responsible for employment of the communications relay UGV under the staff cognizance of the supported unit's G-6/S-6. The UGV would be part of the T/E of the communications unit or detachment of supported units down to battalion level. UGV relays could be attached to companies or even smaller units as necessary to accomplish specific tasks. The UGV would be maneuvered into position and controlled by the communications personnel exercising operational systems control of the tactical communications network. Operational features might include a capability to autonomously maneuver to maintain line of sight and to maintain circuits and ensure quality of service. The UGV communications relay must be fully interoperable with present and future components of the MAGTF tactical communications architecture. The relay's role in the architecture should be completely transparent to the users and operators of tactical radios throughout the MAGTF. It will be used to extend the range of tactical voice and data networks supporting all of the MAGTF warfighting functions -- maneuver, fires, logistics, command and control, intelligence, and force protection.

UGV communications relays must have a limited impact on the amphibious and strategic lift footprint of the MAGTF and must not adversely impact the tactical mobility of supported units. The UGV relay must be suitable for operations in an austere expeditionary environment anywhere in the world. It should be simple enough in operation to permit its employment by radio operators at the small-unit level. It must be supportable under existing and planned Marine Corps supply and maintenance concepts. It should not generate requirements for system-specific test equipment or for specialized operator or maintainer MOSs. Furthermore, formal schools should not be required for operator and maintenance training.

Nuclear, Biological, and Chemical Reconnaissance

- **Overview**

The worldwide proliferation of weapons of mass destruction and long-range delivery systems represents the single greatest threat to the MAGTF. Potential adversaries possess both the means and the demonstrated willingness to employ chemical weapons. The MAGTF must be prepared to operate against an adversary employing chemical, biological, and, possibly although less likely, nuclear weapons. A key element of the MAGTF's NBC defensive capability is the ability to avoid contamination. Contamination avoidance allows the MAGTF to maintain tactical momentum and preserves combat power by keeping soldiers out of increased NBC protective postures. It also removes or lessens the need for decontamination. Contamination avoidance is accomplished through NBC reconnaissance, detection and identification, contamination mapping and marking, and rapid NBC contamination information dissemination.

Currently fielded reconnaissance vehicles depend upon pressurizing and sealing the vehicle to protect the crew from exposure to outside contaminants, and allow the crew to work without the constraints of protective masks and gloves. However, the embarked crew is extremely vulnerable to enemy action while conducting NBC reconnaissance. UGVs offer the ability to conduct NBC reconnaissance tasks, well in advance of the maneuver element, without risking the lives of Marines. The UGV would detect, collect, and analyze contaminants; map and mark contaminated areas; and relay NBC warning data. The availability of this information would allow the MAGTF to better maintain its operational tempo in the face of an NBC threat without unduly degrading its force protection posture. The TOE addressed by this concept is number 2, Nuclear, Biological, and Chemical Reconnaissance (FP-2).

- **Mission**

The primary mission of the UGV in this concept is to conduct NBC reconnaissance in support of MAGTF maneuver elements conducting OMFTS operations. The UGV would employ chemical, biological, and radiological detection systems and mark and map contaminated areas. The UGV would detect and/or classify the type and level of chemical, biological, or radiological contamination. This information would then be relayed to unit NBC control centers. The UGV would be employed well in advance of the forward units of the maneuver element. Based on information provided, the maneuver element would either avoid the contaminated area or take appropriate protective measures to move through the area of contamination.

This concept addresses the following documented deficiencies:

R.18, C26, and C30.

- **Operational Concept**

The UGV will be employed by the GCE well in advance of its maneuver elements to locate, or verify the absence of, NBC contaminants through the use of both stand-off and immediate area detectors. It will include autonomous capabilities for agent or radiation hazard detection, sampling and analysis, meteorological data collection, warning and reporting, and mapping and marking of hazard areas. Use of the UGV will allow the MAGTF commander to preserve his flexibility and freedom of action in the face of an NBC threat.

The post-Cold War era has witnessed the widespread proliferation of weapons of mass destruction and the means of delivery of those weapons. Nowhere is this threat more serious than in the Middle East where the interests of the United States include ensuring continued access to oil, freedom of navigation, security of key regional strategic partners, protection of U.S. citizens and property, and support for human rights and democratic development. The MAGTF must be prepared to defend these national interests. Potentially hostile nations in the region have chemical and biological capabilities and have actually employed such weapons. In its 8-year war with Iran, Iraq used chemical weapons against Iranian troops (as well as against its own Kurdish population) during the 1980s. Iran also employed chemical agents on a limited scale during the war with Iraq. Libya is alleged to have used chemical agents in 1987 against Chadian troops, and Egypt was the first nation in the region to employ chemical agents in the 1963-67 war in Yemen. Iran is in pursuit of a nuclear weapons capability, as was Iraq prior to the Gulf War. Given the capabilities of regional threats and their willingness to use those capabilities, the MAGTF must be prepared to operate against an adversary employing chemical, biological, and, possibly in the not too distant future, nuclear weapons. Adding urgency to the development of NBC defensive capabilities for the MAGTF is the possibility of non-State actors, such as terrorists, acquiring WMD capabilities and employing them against a MAGTF involved in a smaller scale contingency, perhaps a peacekeeping mission.

Marine Corps operations during Desert Shield and Desert Storm represent a real-world example of the employment of NBC reconnaissance vehicles against a significant NBC threat. Ten German-made Fox NBC reconnaissance vehicles were used to support I MEF. Four vehicles were attached to both the 1st Marine Division and the 2d Marine Division. Limited NBC reconnaissance capabilities, including a propensity for a high number of false positive alarms from the Fox, combined with a lack of collective protection capabilities in the AAV-7A1, forced Marines to remain in mission-oriented protective posture (MOPP) suits throughout the operation. Given the lack of air conditioning in the AAV-7A1, it would have been extremely difficult to conduct mounted daytime operations in the Kuwaiti Theater while wearing MOPP gear except during the winter months. This represents an unacceptable limitation on the operational flexibility of the MAGTF and a deficiency that still exists. Fortunately, Iraq never employed its chemical warfare capability in the Gulf War, but the threat was ever present.

NBC monitor/survey teams will use the UGV to conduct NBC reconnaissance and surveillance tasks in all MAGTF operations involving an NBC threat. Through information gathered, MAGTF commanders will gain an appreciation for the operational situation as it relates to NBC hazards. Initial variants of the UGV will be controlled through teleoperation by an NBC monitor/survey team moving with reconnaissance patrols. Improvements in command and control may allow follow-on variants to be controlled semiautonomously from an NBC Control Center. Light armored reconnaissance (LAR) units will employ the UGV in coordination with the manned Joint Services Lightweight NBC Reconnaissance System (JSLNBCRS) (an initial capability might be provided though a teleoperated version of the JSLNBCRS). The UGV will detect contamination, collect and analyze samples, mark contaminated areas, and disseminate NBC data. Data will be relayed to the MAGTF network of NBC Control Centers over the Joint Warning and Reporting Network (JWARN). This data will be used to develop a contamination map of the area, providing all units of the MAGTF with real-time awareness of the NBC situation. This situational awareness will allow commanders to make informed decisions with respect to the scheme of maneuver and the adoption of NBC protective postures.

The UGV must support operations in an austere expeditionary environment anywhere in the world. The UGV must not adversely impact the mobility of supported units and it must be transportable by both VSTOL aircraft and LCACs. For efficient data exchange, the UGV must be compatible with the overall MAGTF C4I architecture. NBC defense specialist training must incorporate instruction on UGV operation. However, the UGV should not require additional MOSs for either operators or maintainers.

Antipersonnel Obstacle and Minefield Breaching

- **Overview**

The Ottawa Treaty, banning the use, production, sale, or stockpiling of antipersonnel land mines, went into effect on March 1, 1999. However, despite the signing of the Ottawa Treaty by 138 governments (as of September 2000) antipersonnel land mines remain in the inventories of nearly all potential adversaries including Russia and China as well as numerous third world nations (including nations that are signatories to the treaty). Land mines offer relatively unsophisticated opponents a cost-effective means to inflict casualties and disrupt the tempo of the MAGTF. The advanced manufacturing and fusing techniques incorporated into modern land mines make them particularly effective and difficult to detect. While nonexplosive obstacles such as barbed wire, walls, hedgehogs, and punji stakes present no new technological challenges, they also represent inexpensive, easily employed ways to adversely impact the mobility of the MAGTF.

Obstacles are normally covered by fire, making mine clearing operations a particularly hazardous undertaking. The current ability of the MAGTF to counter antipersonnel minefields and obstacles consists of the bangalore torpedo. The bangalore torpedo is a manually emplaced, explosive-filled pipe that was originally designed as a wire

breaching device but is also effective against simple pressure-activated AP mines. It is issued as a demolition kit consisting of ten 1.5-meter tubes, each tube weighing 13.2 pounds. It can clear a 1- by 15-meter lane through AP mines and wire entanglements. The bangalore torpedo is being replaced with the Antipersonnel Obstacle Breaching System (APOBS). The APOBS is a two-man breaching system contained in two packs weighing 65 pounds each. It can be deployed in less than two minutes, has a safe stand-off distance of 25 meters, and creates a breach lane 0.6 meters wide by 45 meters long. APOBS significantly improves the capability of Marine Corps ground combat units to breach antipersonnel minefields and wire obstacles. However, APOBS employment still requires two Marines to close on foot to within approximately 25 meters of the target while carrying 65-pound packs. Employment of the APOBS on a teleoperated UGV would greatly reduce the risk involved in breaching antipersonnel obstacles and minefields.

The TOE addressed by this concept is number 3, Antipersonnel Obstacle and Minefield Breaching (M-6).

- **Mission**

The primary mission of the UGV in this concept is to conduct hasty breaching of antipersonnel obstacles and mines. The UGV will use the APOBS to rapidly create lanes through antipersonnel minefields and wire obstacles. Both combat engineers and infantrymen will employ the UGV.

This concept addresses the following documented deficiencies:

R.17, C2, and C26.

This concept also addresses the following undocumented deficiencies:

16 and 17.

- **Operational Concept**

The UGV will be employed in accordance with the *Concept for Future Naval Mine Countermeasures*. This concept calls for, when avoidance is not an option and adequate gaps are not readily identifiable, the capability to conduct rapid, in-stride breaching of the enemy's mines and obstacles. In supporting OMFTS operations, the goal is to streamline the existing deliberate sequence of mine countermeasures actions to achieve a capability that will support rapid maneuver by the elements of the landing force from the ship all the way to objectives located well inland. The landing force must not be constrained by a requirement to attack along prescribed lanes, but must possess the freedom of action to maneuver at will. This demands that MAGTF maneuver elements have the capability of conducting very rapid in-stride breaching operations. The UGV mounting APOBS will contribute significantly to the attainment of this capability, a capability that is essential if

the MAGTF commander is to preserve his operational flexibility and tempo in the face of a significant antipersonnel mine threat.

The Marine Corps concept of maneuver warfare is dependent upon the MAGTF maintaining its mobility and freedom of action. The enemy will attempt to use manmade obstacles and minefields to deny our freedom to maneuver. Mines will typically be employed with other manmade obstacles, such as wire. Obstacles and minefields are relatively inexpensive to construct, quick to emplace, and very effective. Virtually every potential adversary that the MAGTF will encounter in future conflicts has the capability to employ mines and obstacles. In low-intensity conflicts, the enemy will place mines by hand, while more sophisticated opponents will usually have the capability to deliver mines by air or artillery. The level of sophistication of the mines encountered will also depend upon the nature of the threat, although advanced mines are widely available and relatively inexpensive. Typically, enemy forces will use obstacles/minefields to deny advance along selected routes or to channelize maneuver elements into killing zones. The obstacles and minefields will typically be covered by fire and integrated with terrain features. Maneuver elements will attempt to bypass such obstacles. However, bypass may not always be an option. In such cases, breaching operations are necessary to enable further maneuver.

The UGV will be part of the T/E of the combat engineer company of the combat engineer battalion. UGVs and operators will be attached to infantry battalions as necessary to support the scheme of maneuver. The UGV would be used to conduct in-stride breaching of wire obstacles and antipersonnel minefields when such obstacles cannot be avoided. Effective employment of the UGV is dependent upon good intelligence about the location and extent of obstacles and minefields. Normally employed by the combat engineer platoon attached to a battalion landing team, one or more UGVs mounting APOBS will be teleoperated to within approximately 25 meters of the obstacle/minefield and the APOBS fired to create breach lanes. Assault infantry elements will rapidly exploit the lanes created, thus allowing the battalion to maintain a high operational tempo.

The UGV must be deployable by both medium lift helicopters and light tactical vehicles. The UGV should have a minimal impact on the amphibious and strategic lift footprint of the MAGTF. The only data transmitted would be that needed for the operator to control the UGV and to deploy the APOBS. There would be no need for this system to interface with the tactical C4I architecture other than communications.

Point for Infantry

- **Overview**

The potential threats to Marine Corps forces conducting expeditionary operations in the littoral regions range from lightly armed insurgent forces to well trained and equipped combined arms formations. As the basic tactical maneuver unit of the MAGTF, Marine Corps infantry battalions must be prepared to operate against any of these threats across the entire conflict spectrum -- from peacekeeping operations to high-intensity conflict in

an MTW. The lethality of modern weapons, combined with the current emphasis on force protection, demands increased attention to the survivability of the individual infantry Marine.

Perhaps the single most hazardous task assigned to a Marine infantryman is that of walking point or serving as a scout for an infantry unit while moving to contact. Performing this task with a UGV offers significant advantages beyond simply reducing the risk to the infantryman. While reconnoitering potential avenues of advance, the UGV could probe suspected enemy positions, thus minimizing the risk of ambush. By employing several UGVs in reconnaissance-pull tactics, the maneuver unit commander could generate and maintain a high operational tempo by avoiding enemy strong points and preserving his freedom of action. The TOEs that are addressed by this concept include: number 4, Point for Infantry (M-1), and number 7, Close Reconnaissance (I-5).

- **Mission**

The primary mission of the UGV in this concept is to serve as a robotic point for small infantry units while patrolling or moving to contact. The UGV would also be employed in the role of battalion scout operating in advance of the lead company of the battalion. The UGV would provide rapid surveillance and reconnaissance with EO sensors while permitting the unit, including the teleoperator, to remain outside of effective small arms range. The UGV would also be used to probe suspected enemy positions, thus minimizing the risk of unexpected enemy contact. At the battalion level, UGVs would enable reconnaissance-pull tactics by identifying enemy strong points for avoidance and enemy vulnerabilities for exploitation.

This concept addresses the following documented deficiencies:

R.10, R.15, R.16, C2, C5, and C28.

This concept also addresses the following undocumented deficiencies:

1, 2, 5, and 7.

- **Operational Concept**

The UGV would be organic to the H&S company of the infantry battalion. UGVs would be attached to rifle companies as necessary depending upon the operational situation and the scheme of maneuver. The leading platoons of those companies would employ the UGV as the pointman of their lead squad. Tactical direction of the UGV would be at the company level. The UGVs would also be employed by the scout sniper platoon in the role of battalion scout forward of the leading rifle company to reconnoiter the axis of advance. In this case, tactical direction would be at battalion level. When the enemy is detected, the UGV would maintain surveillance while the supported unit either closes and deploys into assault formation or bypasses the enemy position. Although it primarily

serves as a warning device, the UGV could carry a small-caliber automatic weapon to probe suspected enemy positions, prematurely triggering and disrupting enemy ambushes. The UGV would also play a vital role in defensive operations. The UGV would be positioned forward of manned observation and listening posts, providing greater depth to the defensive position and providing early warning of the advance of enemy forces.

Availability of the UGV will allow small-unit commanders to better implement the principles of maneuver warfare. By employing the UGV in reconnaissance-pull tactics the commander can locate gaps in enemy defense for exploitation, without the decisive engagement of a significant portion of his available force. Battalion and company commanders will have real-time information upon which to base tactical decision making. With the risk of ambush nearly eliminated the unit can move boldly, taking advantage of enemy vulnerabilities identified, maintaining speed and momentum, and preserving freedom of action.

The UGV would be highly useful at all levels of conflict. During smaller scale contingencies, such as peacekeeping operations or noncombatant evacuation operations (NEO), the UGV could undertake numerous reconnaissance and surveillance tasks. The strict rules of engagement under which these operations are conducted make the execution of these necessary tasks stressful and highly dangerous. Use of a UGV allows the tasks to be performed while maintaining a satisfactory force protection posture.

The UGV would be a small, stealthy vehicle, projecting a minimal visual and acoustic signature to avoid providing the enemy with early warning of the advance of friendly units. However, given its operating profile, the UGV will be exposed to both direct- and indirect-fire weapons as well as mines and obstacles. In the future, the UGV could also encounter directed-energy weapons targeting the system's electronic components. Against an opponent with an EW capability the system's communications links are potentially vulnerable to detection, jamming, or exploitation.

Teleoperated by a designated operator, the UGV would use EO sensors to detect enemy personnel, vehicles, crew-served weapons, obstacles, and minefields. The UGV must have the capability to transmit and receive control data for teleoperation as well as to transmit real-time sensor data for relay to the battalion headquarters over the tactical communications network. UGV data communications links must be compatible with existing and planned Marine Corps tactical C4I architectures. Situational awareness data collected by the UGV will be relayed from the battalion to higher units for incorporation into the common operational picture.

The UGV must not adversely impact the strategic mobility of the MAGTF or the tactical mobility of the supported infantry unit. This means that the UGV must have mobility, maneuverability, and speed characteristics comparable to dismounted infantry operating both in open terrain and in rough terrain. Furthermore, the UGV must be transportable by all tactical transportation assets including light tactical vehicles and medium lift

helicopters/MV-22s. It must also be deployable by amphibious shipping and strategic airlift and sealift.

Building Reconnaissance, Clearance, and Surveillance

- **Overview**

Probably the most comprehensive U.S. MOUT doctrinal manual available today is Marine Corps Warfighting Publication (MCWP) 3-35.3, *Military Operations on Urbanized Terrain (MOUT*), dated 20 April 1998. This document provides extensive guidance on searching and clearing buildings. While it provides an excellent compendium of current tactics, techniques, and procedures for clearing built-up areas, it reflects current thinking on MOUT. It envisions clearing urban areas block by block, building by building, floor by floor, and room by room. This approach is counter to the maneuver warfare vision described in *A Concept for Future Military Operations on Urbanized Terrain* and is tremendously costly in terms of resources required and time to execute. A single building may be an objective for a rifle squad or, if the building is a large high-rise, for a rifle platoon or even a company. It may be necessary for a unit to enter, search, and clear each building in an assigned sector of the city. A significant amount of time is required for clearing buildings and, because of stress combined with physical exertion, the Marines involved tire rapidly.

Development and fielding of new technologies is necessary if maneuver warfare tenets are to be successfully applied in urban operations. Advanced sensing and locating capabilities are essential to permit the rapid reconnaissance and clearance of buildings and to keep buildings under surveillance once cleared. UGVs represent a potentially effective way to perform these tasks. A micro UGV designed to maneuver within a building could perform covert reconnaissance and surveillance while larger variants could forcibly break into and secure buildings. The TOEs that are addressed by this concept include: number 5, Building Reconnaissance and Clearance (FP-9), and number 26, Building Reconnaissance and Surveillance (I-11).

- **Mission**

The primary mission of the UGV in this concept is to support the planning and execution of building reconnaissance, clearing, and surveillance tasks. Such tasks would be performed by the MAGTF when conducting MOUT operations across the conflict spectrum. The UGV would be employed, covertly if possible, to detect the presence of enemy forces and noncombatants in buildings using advanced sensor technology. Other UGVs could be employed to secure the building using lethal or nonlethal means in coordination with manned patrols or in a standalone mode. After securing the facility, the UGV could be used to maintain surveillance of the facility for whatever period of time necessary to complete the operation. Use of the UGV in this fashion would eliminate the risk of friendly casualties in the hazardous task of building clearance.

This concept addresses the following documented deficiencies:

R.5, R.10, C5, and C26.

This concept also addresses the following undocumented deficiencies:

4, 5, 7, 9, and 18.

- **Operational Concept**

The UGV will be employed in accordance with *A Concept for Future Military Operations on Urbanized Terrain.* As noted above, this concept discards previous urban warfare doctrine in favor of a maneuver warfare approach. Employment of UGVs to conduct building reconnaissance, clearing, and surveillance will greatly reduce the number of Marines that must be dedicated to these tasks. Employing UGVs in this role will help the MAGTF commander to maintain a high level of operational tempo while greatly improving his situational awareness and reducing the risk of casualties. UGVs may be employed to support the MAGTF in MOUT operations against conventional forces, against relatively unsophisticated third world forces, or even against non-state actors (e.g., a hostage situation). Historically, Marine Corps forces have fought in urban terrain in WWII, Korea, Vietnam, and Lebanon. More recent urban operations in Panama City, Port-au-Prince, and Mogadishu proved critical to Operations Just Cause, Uphold Democracy, and Restore Hope and underscore the need for a robust MOUT capability in the MAGTF.

The UGV would be organic to reconnaissance and infantry battalions and to force reconnaissance companies. UGVs and operators would be attached to small units and patrols as necessary to support the operational plan. The UGV would enter, or be inserted, into buildings, covertly if possible, through windows, doors, ducting, delivery chutes, or, if necessary, openings created by demolitions. Operating semiautonomously, day or night, frequently in the presence of obscurants, the UGV would use advanced sensors to investigate the situation on each floor and in each room of the building. The UGV would transmit telemetry and reconnaissance data to be immediately exploited by the supported unit or patrol and to be relayed to the MAGTF Surveillance and Reconnaissance Center (SARC). The UGV would have to be compatible with the overall MAGTF tactical C4I architecture.

Through data gathered by the UGV and using any other available information in the form of building or street plans or perhaps human intelligence, unit commanders would develop a common operational picture and an operational plan to exploit enemy vulnerabilities. In the execution of the scheme of maneuver, small-unit patrols would employ UGVs to clear buildings and place them under surveillance. Buildings would be cleared using either lethal or nonlethal means depending upon the situation and the ROE. Use of the UGV in this fashion will conserve manpower and increase tempo. It will also facilitate operations under restrictive ROE and improve the force protection posture of the units involved in the urban operation.

The UGVs envisioned in this concept would be either micro or miniature. In either case, they would be manportable and easily transported by all tactical vehicles and aircraft and have a minimal impact on the amphibious and strategic lift footprint of the MAGTF or on the tactical mobility of supported units.

Robotic Surveillance and Target Acquisition

- **Overview**

From the development of close air support tactics in Nicaragua to the use of stingray teams in Vietnam, the Marine Corps has led the way in the effective employment of supporting arms. This success is, in large part, due to the proficient use of observers to call in and adjust fire. Forward observers, forward air controllers, and naval gunfire spotters are attached to infantry battalions to perform this task. Reconnaissance teams are also used in a target acquisition role behind enemy lines. For example, in Vietnam 5- to 6-man reconnaissance teams (stingray teams) were inserted deep into enemy controlled territory to interdict enemy units by calling in artillery and air. While the concept was highly successful, it was also a high-risk mission since detection was likely, particularly during insertion and extraction. Personnel endurance factors strictly limited the length of missions. Compromised missions often resulted in heavy friendly casualties.

The use of a UGV offers the ability to conduct target acquisition missions far in advance of friendly units without risking a reconnaissance team. The UGV could also provide long-term surveillance of areas of interest and seal off a landing zone by calling in fires and suppressing targets of all types until L-hour. Unmanned, semiautonomous target acquisition and designation systems would perform the functional role of artillery forward observers, forward air controllers, naval gunfire spotters, and reconnaissance teams. The TOEs that are addressed by this concept include: number 6, Robotic Forward Observer/Target Designator (F-5); number 20, Surveillance (I-4); and number 34, Landing Zone Security (M-11).

- **Mission**

The primary mission of the UGV in this concept is to provide target acquisition support to MAGTF maneuver elements conducting combat operations. Other missions include providing continuous surveillance of landing zones and other areas of interest. The UGV would detect the presence of enemy forces using EO, acoustic, and other advanced sensors. The UGV would identify and accurately locate targets for attack by supporting arms and provide terminal guidance for precision-guided munitions. Following attack it would provide real-time, definitive damage assessment. In a surveillance mode the UGV could ensure the security of landing zones prior to initiation of STOM operations and in the target acquisition and designation mode could seal off landing zones by calling in supporting fires against enemy reaction forces. The UGV would transmit digital target

data directly to the Fire Support Coordination Center (FSCC)/Direct Air Support Center (DASC) of the supported maneuver element.

The UGV would be employed both in a standalone mode and in coordination with manned forward observer teams, tactical air control parties, naval gunfire spotter teams, and reconnaissance teams. Use of the UGV would allow target acquisition and surveillance missions, similar to stingray operations, to be performed deep in enemy-controlled territory without risk to personnel.

This concept addresses the following documented deficiencies:

R.10, R.13, R.15, R.16, C5, C8, C26, and C28.

This concept also addresses the following undocumented deficiencies:

1, 2, 3, 8, 9, 11, 14, and 15.

- **Operational Concept**

The UGV target acquisition system will be employed in accordance with the evolving Marine Corps fire support concepts envisioned in *Advanced Expeditionary Fire Support - the System after Next.* This concept calls for a responsive and reliable first-round fire-for-effect capability, as well as for long-range, precision fires capable of destroying or neutralizing key enemy capabilities. A key element of this concept is a target acquisition system capable of target identification and location under all weather conditions that will allow the MAGTF to more fully exploit the synergistic effect of aviation, ground, and seabased fires. The concept also emphasizes the importance of a reliable BDA capability to be provided through target acquisition sensors. The target acquisition system will be used to support the MAGTF both during the STOM phase of OMFTS operations as well as during sustained operations ashore. During operations other than war conducted under restrictive rules of engagement the system will support precision application of firepower to limit collateral damage and civilian casualties. In all combat environments, by improving the effectiveness of supporting arms, the system will facilitate maneuver and improve protection for the force.

The operating environment in I Corps during the Vietnam War is a good example of a situation in which a UGV-based target acquisition capability would have been particularly useful to MAGTF commanders. In I Corps, as in the rest of the country, large areas of the countryside were under the effective control of the enemy. This allowed the enemy to conduct reinforcement and resupply operations with relative impunity. While III MAF had nearly unlimited supporting arms capability, effective and efficient use of that capability was restricted by limited target acquisition capabilities. Volume of fire was used to compensate for inadequate knowledge of target location. Not only was this approach wasteful of ammunition, it was also responsible for large numbers of civilian casualties in free fire zones. The previously mentioned stingray concept was one technique used to improve target acquisition capability. The concept enjoyed significant

success and inflicted substantial casualties on the enemy. Overall, however, stingray teams did not have a major impact on the enemy resupply effort, and III MAF was never able to seal off I Corps from a steady flow of NVA reinforcements and resupply along well-established enemy lines of communication.

Nearly all combat operations planned or conducted by Marine forces since Vietnam have placed a premium on surveillance and target acquisition efforts deep in enemy territory. This will also be the case in future combat operations. A surveillance and target acquisition UGV would remove the requirement to place manned reconnaissance teams in jeopardy to perform these missions. The UGV would be employed in a manner similar to the current employment of reconnaissance teams, artillery forward observers, forward air controllers, and naval gunfire spotters. It would be a micro or miniature device, small enough to facilitate covert insertion and concealment. It could be inserted by air, perhaps using parafoil delivery or dead drops from momentarily hovering helicopters and tilt-rotor aircraft. It could also be inserted by hand. The insertion points would cover the landing zones and littoral projection points of vertical and surface assault elements or the zones of advance of maneuver elements ashore. It would also be used to cover friendly positions and anticipated enemy avenues of approach during defensive operations. After insertion, the UGV would autonomously seek and occupy a hide location and employ onboard sensors to monitor the area of interest under all weather and visibility conditions. It would detect enemy activity, acquire and locate targets, and designate targets for precision-guided munitions.

The target acquisition UGV would be part of the T/E of artillery firing battalions, reconnaissance battalions, and force reconnaissance companies. UGVs and operators would be attached to MAGTF maneuver elements as necessary to support the scheme of maneuver. After insertion, the UGV would pass target acquisition information to the supported Fire Support Coordination Center/Direct Air Support Center of the unit controlling the operation. Surveillance and reconnaissance data collected by the UGV would be transmitted to the MAGTF Surveillance and Reconnaissance Center for fusion and dissemination to all MAGTF maneuver elements. The UGV must be compatible with the Marine Corps tactical C4I architecture and must interoperate with both current and planned fire support systems to include the Advanced Field Artillery Tactical Data System and the Improved Direct Air Support Center.

Robotic EOD Operations

- **Overview**

A robust EOD capability is necessary to ensure the mobility of the maneuver elements of the MAGTF in the face of hazards posed by large numbers of UXO. A similar capability is needed by the aviation combat element (ACE) to keep runways and facilities free of UXO and operational. Current EOD techniques and procedures are time consuming, manpower intensive, and dangerous to execute. Furthermore, they are inadequate in the face of the threat of submunitions that are likely to be present in large numbers on future battlefields. Submunitions may be encountered as the result of either enemy action or

malfunctioning friendly ordnance. In addition to restricting maneuver, UXO can deny the use of airfields, port facilities, logistic support areas, and lines of communications. UGVs offer the MAGTF a rapid, responsive means of clearing UXO while at the same time reducing the risk facing EOD technicians. EOD teams would remotely operate UGVs to detect, classify, and clear or neutralize UXO. UGVs could also be used to deal with improvised explosive devices (IED), such as car bombs planted by terrorists, when conducting peacekeeping, humanitarian, or other low-intensity conflict operations.

UGVs offer the MAGTF commander the ability to rapidly and safely react to large numbers of UXO in the area of operations. Through the robust and responsive EOD capability provided, the MAGTF can maintain its freedom of action and operational flexibility. The TOE addressed by this concept is number 8, Bomb Detection/Disposal (FP-13).

- **Mission**

The primary mission of the UGV in this concept is to provide the EOD capabilities necessary to rapidly and safely detect, classify, and clear UXO interfering with MAGTF operations. A secondary mission is to provide the capability to deal with boobytraps and other IED. The UGV would be employed by EOD teams operating in direct support of maneuver elements of the GCE during OMFTS and SOA. It would be used as well by EOD teams assigned the responsibility of keeping airfields and rear area facilities free of UXO hazards during SOA.

This concept addresses the following documented deficiency:

C26.

This concept also addresses the following undocumented deficiency:

4.

- **Operational Concept**

A bomb detection/disposal UGV would enable significant improvements in Marine Corps EOD doctrine, tactics, and techniques. This doctrine emphasizes the potential impact of UXO on MAGTF operations on the modern battlefield, especially given the widespread use of submunitions. It also emphasizes the role of EOD in dealing with the threat of IED during military operations other than war. However, the availability of EOD capability is limited and GCE units are often faced with lengthy delays in obtaining necessary support. In current Marine Corps doctrine, EOD is an engineer support function and most EOD capability is centralized in the engineer support battalion. When deployed these capabilities are organic to the combat service support element (CSSE) of the MAGTF. Tasking comes through the staff engineer officer of the supported unit. The availability of a UGV would allow the MAGTF commander to make EOD capabilities more responsive

to maneuver elements by locating them in the combat engineer battalion detachments of GCE units. Tasking would come from the G-3/S-3 of the supported unit.

The primary threat to be countered by the UGV consists of conventional military forces employing antipersonnel and antiarmor submunitions delivered by projectile buses to all parts of the operating zone, to include rear areas. In addition, the UGV will counter larger projectile warheads, some using delayed action or advanced fusing, targeted against high-value installations and facilities. There will be some friendly ordnance items present requiring removal or neutralization. During MOOTW, numerous boobytraps and IED will be encountered and require rapid removal or neutralization.

The UGV will be organic to the combat engineer company of the combat engineer battalion. Depending upon the tactical situation, UGVs and operators will be attached to infantry battalions as part of combat engineer detachments. UGVs would also be organic to the EOD platoon of the engineer support battalion and the EOD section of the Marine wing support squadron. The EOD section of the Marine wing support squadron will support the aviation combat element with a primary focus on keeping expeditionary airfields and forward arming and refueling points cleared of UXO and operational. The UGVs will be employed by combat engineer detachments and response teams from the EOD platoon to maintain the mobility of maneuver elements in the face of the hazards posed by UXO and IED anywhere in the area of operations.

Initial variants of the UGV will be controlled through teleoperation by a designated operator while future variants may operate semiautonomously. Data collected by the UGV will be relayed to the combat operations center (COC) of the supported unit as well as to the MAGTF's EOD headquarters, normally part of the CSSE. This information will be further disseminated to all elements of the MAGTF that could be impacted. These UGVs operate under engineer direction, and initial variants would require little interface with the overall MAGTF C4I architecture, but should be compatible with the tactical communications network. Future generations, capable of semiautonomous operation, would require a greater degree of interoperability with MAGTF C4I systems. The UGV will be carried or towed to the area of operations and must be small enough to be deployable by medium lift helicopters/MV-22s and light tactical vehicles. It should fit within the current amphibious and strategic lift footprint of the MAGTF.

Route Reconnaissance

- **Overview**

An important maneuver warfare concept, central to successful OMFTS operations, is the exploitation of enemy weaknesses through reconnaissance-pull tactics. For the MAGTF to employ reconnaissance pull, it must have robust and responsive reconnaissance and scouting capabilities to rapidly ascertain the viability of alternate avenues of advance. Such capabilities are currently provided by LAR units as well as by reconnaissance patrols conducted on foot or mounted in light tactical vehicles or on motorcycles. All of these techniques have drawbacks. Route reconnaissance on foot is slow, while light

tactical vehicles and motorcycles are too vulnerable to use in high-threat environments. LAVs, with their armor, firepower, and organic scouts, provide the best route reconnaissance capabilities currently available to the MAGTF. However, the visual, thermal, and acoustic signatures of the LAV tend to forfeit tactical surprise, and the LAV's size restricts its employment in deep reconnaissance or advance force operations as well as in support of the vertical assault.

A small, highly mobile UGV could address many of the deficiencies described above. Operating well in advance of maneuver elements it would determine trafficability and detect mines, obstacles, and enemy units along potential avenues of advance. It would improve force protection by reducing the threat of ambush and by reducing the need for high-risk manned reconnaissance efforts. The TOE addressed by this concept is number 9, Route Reconnaissance (I-2).

- **Mission**

The primary mission of the UGV in this concept is to provide rapid route reconnaissance to determine the suitability of avenues of advance. Secondary missions would include providing continuous surveillance of areas of interest. In performing route reconnaissance the UGV would determine the trafficability of planned routes and detect the presence of enemy forces and obstacles using EO, acoustic, and other advanced sensors. Using these sensors it could overwatch selected routes of advance and areas of interest.

The UGV would be employed both in a standalone mode and in coordination with manned reconnaissance and screening elements. Use of the UGV would greatly enhance the capabilities and extend the operational reach of the LAR battalion and other MAGTF units assigned to reconnaissance missions.

This concept addresses the following documented deficiencies:

R.10, R.15, and C5.

This concept also addresses the following undocumented deficiencies:

1, 5, and 7.

- **Operational Concept**

The UGV would be organic to both LAR and reconnaissance units. It would support LAR units conducting scouting, screening, and reconnaissance operations. In support of LAR units it would operate in coordination with manned LAVs acting as the eyes and ears of the LAV-25 in a role similar to that of the LAV infantry scout. The UGV would support rapid investigation of not only primary roads, but also adjacent terrain to include defiles and lateral routes, which might or might not be trafficable by an LAV. The UGV would be used to scout areas and points of interest where the danger of enemy contact

appears great. For deep reconnaissance or advance force operations the UGV could be employed by MAGTF reconnaissance units in concert with manned or unmanned aircraft to relay sensor data from the UGV to the MAGTF SARC. The UGVs could scout planned avenues of advance and maintain continuous surveillance of critical locations, such as landing zones for helicopters and landing craft. The use of the UGV would significantly increase the rate of reconnaissance of both mounted and dismounted reconnaissance units.

The UGVs could also be attached in direct support of infantry units. These UGVs would operate semiautonomously under the control and tactical direction of the COC of the supported unit. Reconnaissance data collected by the UGV would be transmitted directly to the COC of the supported unit. With this real-time information the commander at any level could make in-stride adjustments to his scheme of maneuver to avoid enemy strengths and to take advantage of enemy weaknesses.

The UGV would be towed or carried to the area of employment by light tactical vehicles or the LAV. It would be a small, highly mobile, and stealthy vehicle generating a low visual, acoustic, and thermal signature to reduce the probability of detection. It would be small enough to allow insertion by medium lift helicoper/MV-22. The UGV must be compatible with the Marine Corps tactical C4I architecture and be interoperable with both the tactical combat operations system (TCO) and the intelligence analysis system (IAS).

Small-Unit Base of Fire

- **Overview**

OMFTS operations conducted against deep inland objectives place a premium on readily available organic firepower to rapidly suppress and neutralize the enemy. All Marine units, from the MEF to the fire team, base offensive operations on the ability to exploit the synergistic effects of fire and maneuver. At the small-unit level the M240G medium machine gun serves as an effective base of fire. However, machine gun crews are a high-priority target vulnerable to enemy counterfire. A UGV with a direct-fire capability could provide a base of fire without exposing a machine gun team to enemy attack and thus remove the need for a fire team or a squad to provide security. The UGV would provide a base of fire during the assault and then displace to cover the exploitation and consolidation phase of the operation. When employed in defensive operations, these UGVs could eliminate gaps in and extend the depth of final protective fires. The TOE addressed by this concept is number 10, Rifle Squad/Fire Team Base of Fire (F-1).

- **Mission**

The primary mission of the UGV in this concept is to provide a base of fire to suppress or neutralize enemy forces during offensive operations. The UGV would directly support the assault of an objective by a rifle platoon or a rifle squad. The secondary mission of

the UGV would be to anchor the final protective fires of a rifle company during defensive operations.

This concept addresses the following documented deficiencies:

R.15 and C10.

This concept also addresses the following undocumented deficiencies:

2, 6, and 18.

- **Operational Concept**

The employment of a direct-fire UGV will facilitate the implementation of maneuver warfare principles at the small-unit level of the MAGTF. It will provide small-unit commanders with greater operational flexibility in the integration of fire and maneuver. The UGV can occupy relatively exposed positions untenable by humans with no requirement for a fire team or a squad to provide security for the automated base of fire. In many instances this would allow a base-of-fire UGV to bring more accurate fires on a target area than would be possible with a manned machine gun. However, many of the principles governing the employment of manned machine guns will also apply to the employment of direct-fire UGVs. These include positioning the UGV to provide enfilade fire and interlocking fires and enforcing economy of fire. Fires from the UGV would be coordinated with the fires of manned direct- and indirect-fire weapons to achieve maximum impact on the enemy during all phases of the offensive -- preparation of the objective, final assault, consolidation, and pursuit by fire.

In defensive operations, the direct-fire UGV would form the backbone around which other company weapons are oriented for final protective fires. Normally, a UGV would be assigned a final protective line (FPL). However, UGVs could be assigned a principal direction of fire (PDF) to cover dead spaces and likely avenues of approach. UGVs could also be positioned forward of the main defensive position, thereby extending the depth of the position allowing earlier engagement and disruption of enemy attacks.

These small, teleoperated direct-fire UGVs could be employed throughout the MAGTF to either augment or replace medium machine guns. Even smaller versions could potentially replace the squad automatic weapon while larger versions could potentially replace infantry battalion heavy machine guns. The UGV in this particular concept is envisioned as a replacement for the medium machine gun organic to the rifle company. Both UGVs and operators would be organic to the weapons platoon of the rifle company.

In the defense the company commander would control the employment of the UGV. In the offense UGVs and operators would normally be attached to rifle platoons to support the company scheme of maneuver. However, depending upon the situation, UGVs could remain in general support of the company or in other instances be attached directly to

rifle squads. Target data would be sent to the UGV operator, who would engage according to the supported unit commander's direction.

These UGVs would have relatively austere sensor suites, but would be capable of operation under conditions of reduced visibility and would have target acquisition capability superior to unaided eyesight. Data exchange requirements would be limited to those needed for the teleoperation of the UGV and its weapon. Since tactical direction would remain at company level or below, there would be no need for this system to interface with the overall MAGTF C4I architecture.

The UGV would be transported to the general area of employment by rotary-wing aircraft or light tactical vehicle. However, it must be capable of being manpacked over terrain not feasible for vehicles, perhaps carried in several packages by operators. This UGV should have a minimal impact on the amphibious and strategic lift footprint of the rifle company and must not inhibit its foot mobility.

Remote EW Operations

- **Overview**

On the modern battlefield, success is highly dependent on domination of the electromagnetic spectrum. Both the MAGTF and its future adversaries are dependent upon equipment operating within the electromagnetic spectrum for communications, navigation, information gathering, and the detection, location, and identification of enemy forces. By preventing the enemy from effective use of the electromagnetic spectrum, while preserving its own freedom to use the same spectrum, the MAGTF gains an important advantage. Consequently, the Marine Corps devotes significant resources to maintain the electronic warfare capabilities, both air and ground, of the MAGTF.

This concept focuses on the potential use of a UGV to support ground-based electronic warfare. Current and planned manned EW systems organic to the radio battalion, while providing effective support, have significant limitations. These systems are extremely vulnerable to enemy attack and normally operate behind forward maneuver elements. In this location they can be masked by terrain and may be beyond the effective range of their interception capabilities. An unmanned system could be inserted well forward of maneuver elements and deep into enemy controlled territory to perform EW tasks. The TOEs that are addressed by this concept include number 11, Electronic Warfare (I-10).

- **Mission**

The primary mission of the UGV in this concept is to provide EW support to the MAGTF conducting OMFTS and SOA operations across the entire spectrum of conflict. The EW UGV would conduct radio direction finding, interception recording, and relay of enemy communications and non-communications signals. It would also selectively jam enemy

emitters. The UGV could be employed either in coordination with manned radio battalion systems or in a standalone mode.

This concept addresses the following documented deficiencies:

R.10 and C11.

This concept also addresses the following undocumented deficiency:

1.

- **Operational Concept**

The UGV would be employed in accordance with the Marine Corps EW doctrine to support MAGTF maneuver elements. Availability of the EW UGV would allow the radio battalion to provide greater depth and responsiveness to its EW support. It would provide a capability for radio reconnaissance and other EW operations deep in enemy territory without risk to radio battalion personnel or the vertical assault support assets required to insert and extract them. Operations previously considered too dangerous could be undertaken using the EW UGV. The EW UGV would participate in the conduct of advance force and preassault amphibious operations and operate in advance of friendly forces during the amphibious assault and sustained operations ashore.

Potential adversaries are well aware of the threat posed by MAGTF EW capabilities and attempt to target those capabilities for neutralization or for exploitation. EW UGVs could occupy positions too dangerous for manned teams, but advantageous for electronic reception. Threats to the EW UGV would include direct- and indirect-fire weapons and possibly directed-energy weapons designed to produce physical damage to internal electronic components.

The EW UGV would be organic to the radio battalion and employed by radio reconnaissance teams. Deep insertion operations would be under MAGTF control, but depending upon the situation, UGVs could be attached, as part of radio reconnaissance teams, to maneuver units of the GCE of the MEF. UGVs would also be part of radio battalion signals intelligence (SIGINT) support units assigned to the command element of smaller MAGTFs (MEBs and MEUs). The UGV would be inserted either by air, perhaps by parafoil or rotary-wing aircraft, or by hand and maneuver autonomously to a hide position. It would be small enough to evade enemy detection and would activate on schedule or command to disrupt enemy communications and to search for, identify, collect, and relay electronic signals for exploitation.

Depending upon the situation, EW UGVs could operate either in a standalone mode or as part of an integrated radio battalion effort in coordination with manned systems such as the team portable communications intelligence system (TPCS) and the mobile electronic warfare support system (MEWSS). Intercepted signals would be passed to the radio battalion operations control and analysis center for exploitation. Jamming activities

would be coordinated through the MAGTF electronic warfare control center to ensure integration of all MAGTF offensive electronic warfare operations as well as deconfliction with friendly communications and information systems. The UGV would be interoperable with and have data communications connectivity to other radio battalion SIGINT/EW systems such as TPCS, MEWSS, and the technical control and analysis center (TCAC) as well as other MAGTF tactical C4I systems to include the IAS.

Neutralizing Fortified Positions

- **Overview**

While maneuver warfare emphasizes avoiding enemy strengths and attacking enemy weaknesses, this is not always possible. Marine Corps units will never have a perfect picture of enemy dispositions. Furthermore, in some instances, e.g., Desert Storm, MAGTF maneuver elements encounter fixed enemy positions that are too large to bypass or where no bypass can be made. On these occasions, maneuver elements may have to assault fortified positions. The Marine Corps is significantly enhancing its antiarmor capabilities at the infantry battalion level with the fielding of the Javelin and the Predator. However, these weapons make no improvement to the ability of the maneuver battalion to overcome fortified positions. The infantry battalion's most effective weapon against field fortifications remains the SMAW. While effective against both masonry structures and sandbag and timber bunkers, the SMAW does have significant limitations. The maximum effective range against a 1- by 2-meter target is 250 meters. Furthermore, the weapon has a significant firing signature due to its backblast. Before and after firing, the SMAW gunner is a high-priority target, visible and vulnerable to enemy fire. A UGV specifically designed to operate against fortified positions could significantly reduce the risk to Marine infantrymen in such operations. UGVs could use a wide variety of lethal means to destroy or neutralize fortified targets ranging from precision emplacement of satchel charges to dispensing flame. UGVs of this type could also provide a flexible means of engaging fortified positions in an urban environment with nonlethal weapons. The TOEs that are addressed by this concept include number 12, Assault on Fortified Positions (F-4), and number 46, Robotic Flamethrower (F-2).

- **Mission**

The primary mission of the UGV in this concept is to support small infantry units in assaulting fortified positions. The UGV would equip the assault section of the weapons platoon, rifle company and be used in a functional role similar to the SMAW. Depending on the situation the UGVs could be used with a variety of lethal or nonlethal payloads to destroy or neutralize the threat.

This concept addresses the following documented deficiencies:

R.5, R.15, and C10.

This concept also addresses the following undocumented deficiencies:

2, 6, and 12.

- **Operational Concept**

The UGV and operator will be organic to the assault section of the weapons platoon of the rifle company and will normally be attached to a rifle platoon or squad to support the company scheme of maneuver. The availability of the UGV will enable small-unit commanders to rapidly neutralize enemy strongpoints located in their zones of action without the necessity of calling in lengthy and sometimes ineffective preparatory fires prior to assaulting. This capability will allow MAGTF maneuver elements at the small-unit level to maintain operational flexibility and a high tempo of operations even against well-prepared defensive positions. It will also enhance the survivability of those units tasked with attacking those positions.

The employment and the payload of the UGV will be based upon a detailed reconnaissance of the objective to determine its characteristics and the locations of defending troops and supporting emplacements. The assault UGVs may be employed in concert with other UGVs dedicated to clearing lanes through antipersonnel obstacles/minefields. The platoon commander or squad leader will employ the UGV just in advance of his assault elements and cover the employment with his base of fire. The UGV operator will remain with the base of fire to minimize exposure. Immediately following delivery of the UGV payload, while any surviving defenders are incapacitated, manned assault elements will secure the objective.

The assault UGV will be particularly valuable in the conduct of operations in urban environments. Buildings, constructed of a wide variety of materials, offer nearly unlimited opportunities for an urban defender to create strongpoints often in the middle of civilian population centers. Through selective employment of lethal and precision-delivered nonlethal payloads, such strongpoints could be neutralized while remaining within the rules of engagement, minimizing collateral damage and civilian casualties, and maintaining force protection posture.

The assault UGV would be simple and expendable, although it would withstand small arms fire. It would be controlled through teleoperation by a designated operator remaining with a base of fire in the attack. Command, control, and communications considerations would be limited. The only data that would be exchanged would be between the operator and the UGV for control of the UGV and delivery of the UGV payload. The sensor package would be unsophisticated, but would, at a minimum, permit effective employment at night and under conditions of reduced visibility. Tactical direction would be at the company level and there would be no requirement for this close-combat, short-ranged device to enter the tactical C4I architecture.

Payloads for the assault UGV could include satchel charges, flame dispensers, rockets, large demolitions, and a variety of nonlethal weapons. The UGV would not be manportable, but would be deployable to the general area of employment by medium lift helicopters and light tactical vehicles. The UGV should have a minimal impact on the amphibious and strategic lift footprint of the MAGTF.

Combat Patrolling

- **Overview**

Small units conduct combat patrols in both offensive and defensive operations across the entire conflict spectrum. Combat patrols are conducted to inflict damage on the enemy and keep him off balance; to establish and/or maintain contact with friendly and enemy forces; to deny the enemy access to key terrain and friendly positions; and to probe enemy positions to determine the nature and extent of enemy defenses. The conduct of combat patrols is fundamental to the force protection posture for the MAGTF. Aggressive patrolling by MAGTF units disrupts and deters enemy action. Any lapse in patrolling efforts exposes the MAGTF to the almost immediate danger of enemy action and risks forfeiture of initiative to the enemy with potentially costly results. However, constant patrolling exacts a significant toll on the Marines involved. Patrolling is a particularly fatiguing and hazardous task and tends, over time, to reduce the combat effectiveness of the units assigned to conduct the patrols. Furthermore, patrols conducted on foot are limited in speed, range, and area of coverage. Mounted patrols, on the other hand, are restricted to relatively open terrain and consequently limited in their coverage of the area of concern.

During any conflict, the MAGTF will conduct covering force operations to provide essential protection from and warning of enemy activity. Marine Corps forces fought numerous covering force actions prior to the initiation of the UN ground offensive in the Gulf War. These actions defeated Iraqi spoiling attacks directed against I MEF forces and maintained the security posture of major I MEF units while inflicting significant damage on Iraqi forces. During the final year of the Korean War, outpost battles characterized the operations of the 1st Marine Division. The execution of these past covering force operations has been governed, to some extent, by a concern over the safe withdrawal of covering force units.

A UGV specifically designed to conduct unmanned combat patrols and covering force operations could make a major contribution to MAGTF operations in both conventional combat and military operations other than war. The employment of UGVs in these roles would minimize the exposure of Marines and extend the normal range of observation and action. The UGVs would be fitted with advanced sensors and target acquisition/designation devices as well as both lethal and nonlethal direct-fire weapons. The TOEs addressed by this concept include: number 13, Combat Patrolling (FP-5); number 45, Covering Force (FP-4); and number 47, Remote Attack/Ambush (M-10).

- **Mission**

The primary mission of the UGV would be to conduct combat patrols in both offensive and defensive operations. The UGVs would perform all combat patrolling tasks including raids, contact patrols, ambushes, and security patrols. Operating under appropriate rules of engagement, UGVs could be used in operations other than war as well as in conventional operations. The UGV would be employed under positive control of the supported unit COC or rear area operations center (RAOC). Use of the UGV for patrolling would enhance the security posture of the MAGTF and serve as a valuable economy-of-force measure, reducing the need to assign small units to combat patrolling duties.

A secondary mission would be to support covering force operations. In the covering force role, UGVs could extend security areas far forward and the UGV could also be used to seal off landing force objectives from enemy reinforcement and counterattack. During SOA, UGVs in the covering force could provide early warning of the enemy advance, engaging the enemy in order to damage, delay, disrupt, and deceive as to the true location of the main battle area. As the enemy closes, the UGVs would maintain contact while falling back under pressure, in concert with the movements of the manned covering force units.

This concept addresses the following documented deficiencies:

R.10, R.15, R.16, C3, C26, and C28.

This concept addresses the following undocumented deficiencies:

2 and 11.

- **Operational Concept**

The UGV would be employed in a standalone mode when conducting raids and ambushes both for maximum flexibility and to reduce the risk of fratricide. In these assignments the UGV would operate semiautonomously in an assigned area, but target engagement decisions would be controlled by the supported COC. An expendable variant of the UGV might be used to conduct deep raids and ambushes. Such UGVs would be inserted in the enemy's rear area, perhaps as part of an advance force operation or a deception, and set to operate in a fully autonomous mode. With self-destruct and anti-tampering protocols activated, such UGVs could inflict significant damage, cause the enemy to react prematurely, and unhinge enemy defenses. When out of ammunition and power, they would self-destruct. The UGV would also be used in contact patrols, security patrols, as well as covering force operations to protect the flanks of units moving to contact, defensive positions, and rear area facilities and units.

UGVs would be particularly valuable in improving the force protection posture of the MAGTF by protecting friendly forces and facilities against insurgent or terrorist attack during operations other than war. The positioning of a UGV in a civilian area may prove less provocative than manned outposts and checkpoints while still providing needed security. The situation facing Battalion Landing Team (BLT) 1/8 in Beirut in 1983 is an excellent example of just such a scenario. UGV security patrols could have reconnoitered the positions from which the BLT was receiving fire and denied the enemy freedom of action and observation. The UGV could also make significant contributions during MOUT operations by conducting highly visible, unmanned security patrols to detect and deter enemy activity. A UGV patrol could adhere to restrictive rules of engagement that might well jeopardize manned patrols. During all MAGTF operations, the use of UGVs would be a valuable economy-of-force measure, sparing Marines from fatiguing, boring, and dangerous duty while maintaining a high level of force protection.

The UGV would be highly mobile, mounting sensors, target designation devices, and direct-fire weapons, both lethal and nonlethal. It would be small enough to allow insertion by medium lift helicopter/MV-22. It would be towed or carried to the area of employment by tactical vehicles. The UGV would be organic to both infantry and light armored reconnaissance battalions and to MP units. The battalion would control the UGV at the battalion level from the COC. MP units would assign the vehicle to conduct rear area security tasks under control of the RAOC. Since combat patrolling, especially in the rear area, always runs the risk of fratricide, UGV combat patrols would be carefully coordinated with all other ongoing friendly activities. UGV patrols would be based on real-time information on the disposition of friendly forces as well as the best available intelligence with respect to the enemy situation. As with manned patrols, UGV patrols would be conducted with rigorous adherence to the ROE governing the operation.

In the conduct of the covering force operation, battalions assigned to the covering force would employ their UGVs to overwatch exposed combat outposts and likely avenues of approach. These UGVs would alert the manned elements of the covering force to the presence of enemy forces. The UGVs would drive off small probes and inflict maximum damage and disruption upon attacking enemy forces while covering the withdrawal of manned units in the face of a major enemy effort.

The UGV could engage enemy forces either with onboard weapons or by locating and designating targets for attack by supporting arms. The UGV would pass information to and request engagement authority from either the COC or the RAOC as appropriate. Target acquisition information would be passed directly to the supported unit FSCC/DASC. The communications link would often, depending on the situation, be required to function over beyond-line-of-sight distances. The UGV must be compatible with the Marine Corps tactical C4I architecture and be interoperable with the TCO system, the Advanced Field Artillery Tactical Data System, and the Improved Direct Air Support Center.

Urban Operations

- **Overview**

Increasing urbanization in the developing world, much of it taking place along the littorals, makes it likely that Marines will be called upon to conduct future operations in urban environments. Such environments present unique challenges; urban terrain is highly restrictive, limiting observation and fields of fire and reducing mobility. At the same time, urban terrain provides defenders with nearly unlimited opportunities for cover and concealment. Urban conflict involves close combat with troops fighting block to block, building to building, and even room to room while the employment of supporting arms is restricted. The environment tends to interfere with radio communications, exacerbating an already difficult command and control situation. The biggest challenge, however, is the presence of large numbers of noncombatants often interspersed with the enemy. This leads to restrictive ROE that force the MAGTF commander into difficult tradeoffs between mission accomplishment and adequate force protection. Urban warfare allows an unsophisticated opponent to negate many of the inherent advantages of the MAGTF.

UGVs offer the MAGTF commander the ability to operate more effectively in an urban environment. Employing UGVs the MAGTF commander can maintain a satisfactory force protection posture, even under the most restrictive of ROEs. Furthermore, UGVs offer the means to overcome many of the challenges posed by the urban environment. UGVs can be used both for reconnaissance and surveillance and to employ nonlethal weapons or to ensure precision employment of lethal weapons. The TOEs that are addressed by this concept include number 14, Urban RSTA (I-7); number 15, Urban Warrior (FP-8); and number 21, Countersniper (FP-10).

- **Mission**

The primary mission of the UGV in this concept is to support small units conducting MOUT operations. The UGV would be employed to detect the presence of enemy forces and noncombatants using EO, acoustic, and other advanced sensors. The UGV could be employed in coordination with manned patrols or in a standalone mode. The UGV would be used, with either nonlethal or lethal payloads depending on the situation and the ROE, for crowd control and area denial operations. Use of the UGV would allow precision delivery of riot-control and incapacitation agents. The UGV could close with and disarm or neutralize a sniper, gunman, crew-served weapon, or hostage holder with minimal risk to noncombatants and Marines.

This concept addresses the following documented deficiencies:

R.5, R.10, C5, C26, and C28.

This concept also addresses the following undocumented deficiencies:

3, 4, 5, 7, 9, 10, 11, 12, 15, 16, 17, and 18.

- **Operational Concept**

The UGV will be employed in accordance with the Marine Corps concept for future operations in urban terrain. This concept discards previous urban warfare doctrine in favor of a maneuver warfare approach. Traditional attrition-style urban warfare is costly in terms of friendly casualties and the impact on civilian populations. The Marine Corps maneuver approach to urban conflict envisions identifying enemy centers of gravity and critical vulnerabilities and conducting rapid operations aimed at unhinging the enemy's ability to act. The UGV will allow the MAGTF commander to act boldly to rapidly identify and exploit enemy weaknesses.

Urban areas present an extraordinarily complex operating environment. Manmade structures are superimposed on natural geographic features. Buildings are constructed of a wide variety of materials and when damaged can radically alter the nature of the terrain. The threat encountered will be as diverse as the terrain itself. In some cases conventional forces may use cities as strong points in defensive operations. More often, relatively unsophisticated insurgent forces or other non-state entities will exploit urban areas and populations to advance their causes and to offset the military advantages enjoyed by the U.S. Such smaller scale contingencies may range from the taking of hostages by terrorists to attempts to overthrow friendly governments through urban insurgencies. Recent international peacekeeping efforts have focused on restoring order in populated areas by curbing banditry and civil unrest.

A typical operating environment is represented by that facing U.S. and allied forces in and around Mogadishu, Somalia in 1993. The tactical setbacks of October 3rd and 4th graphically demonstrated the potential downside of deploying conventionally-armed U.S. forces against the asymmetric threat posed by lightly armed, poorly trained belligerents in an urban environment, especially one with a population supportive of the threat. Marine Corps MAGTFs may well expect to face similar scenarios in the future. UGVs offer an attractive means of resolving existing deficiencies in the ability of the MAGTF to conduct military operations in urban terrain.

Employed at the battalion level and below, in coordination with manned reconnaissance efforts, the urban combat UGV will initially be used to conduct surveillance and reconnaissance of both zones and points of interest. Through information gathered, MAGTF commanders will gain an appreciation for the operational situation and identify gaps and opportunities. Based on this intelligence, MAGTF commanders will create and maintain tempo with manned combat patrols or larger units employing UGVs to rapidly neutralize threats and secure objectives. The UGV will support operations even under the most restrictive ROEs, enabling small units to rapidly gain control of the situation through employment of nonlethal weapons. In more intensive combat, the UGV can deliver lethal munitions with pinpoint precision or, if necessary, designate targets for

supporting arms. The UGV will act as a surrogate point for urban patrols reconnoitering axes of advance, by fire when necessary. Snipers and ambushes will be located and neutralized prior to exposing Marines. Strongpoints and pockets of resistance can be eliminated with little or no collateral damage.

While not necessarily manportable, the UGV must be easily deployable by medium lift helicopters and light tactical vehicles. The UGV should have a minimal impact on the amphibious and strategic lift footprint of the MAGTF. The urban UGV will be part of the T/E of the H&S company of the infantry, reconnaissance, and LAR battalions. UGVs and operators will be attached to rifle companies as necessary to support the battalion scheme of maneuver.

The UGV will be controlled through teleoperation by a designated operator moving with an urban patrol. Reconnaissance data collected by the UGV will be transmitted to the patrol or the unit controlling the operation and automatically relayed to the MAGTF Surveillance and Reconnaissance Center and integrated into the overall intelligence picture. Target acquisition information will be passed to the Fire Support Coordination Center of the unit controlling the operation. Engagement decisions will be made according to paragraph five of the operations order and the existing ROE.

4. SUMMARY

This section integrates the work done by the study team in developing COEs with the technology assessment contained at Appendix E. The technology assessment was coordinated by the UGV/S JPO. The assessment investigated the technological maturity of each of the NOEs in each of five areas: intelligence, sensors, mobility, C3, and Marine machine interface (MMI). For each NOE technological maturity was assessed in each technology area. Scores were assigned as levels one through four, with one being the least mature and four being the most mature. The level of technological maturity was assigned based on where that particular technology stood in the R&D cycle. A one was assigned for technology in basic research, a two for technology in applied research, a three for technology in advanced development, and a four for technology in engineering and manufacturing development.

Table 6. Technological Maturity

COE Title	NOE #	NOE Title	Technological Maturity				
			INTEL	SENSORS	MOBILITY	C3	MMI
Communications Relay	1	Communications Relay	4	3	3	3	3
Nuclear, Biological, and Chemical Reconnaissance	2	Nuclear, Biological, and Chemical Reconnaissance	2	2	2	3	3
Antipersonnel Obstacle and Minefield Breaching	3	Antipersonnel Obstacle and Minefield Breaching	4	4	3	4	4
Point for Infantry	4	Point for Infantry	4	3	2	3	2
	7	Close Reconnaissance	4	4	3	4	3
Building Reconnaissance, Clearance, and Surveillance	5	Building Reconnaissance and Clearance	2	2	2	3	3
	26	Building Reconnaissance and Surveillance	2	2	2	3	3
Robotic Surveillance and Target Acquisition	6	Robotic Forward Observer/Target Designator	2	2	3	2	3
	20	Surveillance	1	1	3	1	2
	34	Landing Zone Security	1	2	3	3	3
Robotic EOD Operations	8	Bomb Detection/Disposal	4	2	3	3	3
Route Reconnaissance	9	Route Reconnaissance	2	2	2	3	3
Small-Unit Base of Fire	10	Rifle Squad/Fire Team Base of Fire	4	3	3	3	2
Remote EW Operations	11	Electronic Warfare	1	2	2	3	3
Neutralizing Fortified Positions	12	Assault on Fortified Positions	4	4	3	4	3
	46	Robotic Flamethrower	4	4	4	3	4
Combat Patrolling	13	Combat Patrolling	2	2	2	3	3
	45	Covering Force	1	2	2	2	3
	47	Remote Attack/Ambush	1	2	2	2	3
Urban Operations	14	Urban RSTA	4	3	2	3	3
	15	Urban Warrior	4	3	2	2	2
	21	Countersniper	4	2	2	2	2

Table 6 above depicts the maturity level assigned in each of the five technology areas for each of the 13 COEs. The maturity level assigned in the first two technology areas, intelligence and sensors, is directly dependent on the control mode of the UGV. The three control modes are: teleoperation,[1] semiautonomous operation,[2] and autonomous operation.[3] The intelligence technology area, which includes perception and cooperative behavior, is generally assessed at level one for COEs requiring autonomous operation and level four for COEs using teleoperation. Similarly, for the sensor technology area, the maturity level is significantly lower for those COEs requiring autonomous operation. The mobility technology area, while in general more mature than the first two areas, is still not mature enough to fully support any of the COEs. The maturity levels of the last two technology areas, C3 and MMI, with only a few exceptions, are equal to or greater than the maturity levels of the other three technology areas.

As shown in Table 6, none of the COEs were assessed as level four in all technology areas (based on the technology level of associated NOEs). However, three of the COEs were assessed at level three or above in all technology areas. Based on the technology assessment, it appears that these COEs (Communications Relay, Antipersonnel Obstacle and Minefield Breaching, and Neutralizing Fortified Positions) would pose the least technological risk in development and fielding.

[1] Teleoperation. A mode of control of a UGV wherein the human operator, using video feedback and/or other cues, directly controls on a continuous basis the actions of the UGV.

[2] Semiautonomous operation. A mode of control of a UGV wherein the human operator plans a mission for the UGV, it conducts the assigned mission, and requires human operator intervention only when the UGV needs further instructions.

[3] Autonomous Operation. A mode of control of a UGV wherein the UGV is self-sufficient. The UGV is given its global mission by the human, having been programmed to learn from and respond to its environment, and operates without further human intervention.

Appendix A

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Appendix B

Acronyms

AAAV	Advanced Amphibious Assault Vehicle
AAN	Army After Next
ACE	Aviation Combat Element
ACTD	Advanced Capabilities Technology Demonstration
AFRL	Air Force Research Laboratory
AHP	Analytic Hierarchy Process
AMRDEC	Aviation and Missile Command Research, Development and Engineering Center
APOBS	Antipersonnel Obstacle Breaching System
ARC	Active Range Clearance
ARL	Army Research Laboratory
ARS	Advanced Robotics Systems
ARTS	All-Purpose Robotic Transport System
ATD	Advanced Technology Demonstration
BDA	Battle Damage Assessment
BUGS	Basic UXO Gathering System
CAT	Crew Integration and Automation Testbed
CETO	Center for Emerging Threats and Opportunities
COC	Combat Operations Center
COE	Concept of Employment
CONUS	Continental United States
COR	Contracting Officer's Representative
CP	Command Post
CSSE	Combat Service Support Element
C2	Command and Control
C4I	Command, Control, Communications, Computers, and Intelligence
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
DARPA	Defense Advanced Research Projects Agency
DASC	Direct Air Support Center
DOD	Department of Defense
ECCM	Electronic Counter Countermeasures
EO	Electro-Optics
EOD	Explosive Ordnance Disposal
EW	Electronic Warfare
FCS	Future Combat Systems
FPL	Final Protective Line
FSCC	Fire Support Coordination Center
GCE	Ground Combat Element
HMI	Human Machine Interface
IAS	Intelligence Analysis System
IED	Improvised Explosive Devices
IO	Information Operations
IPR	In-Progress Review
JAUGS	Joint Architecture for Unmanned Ground Systems
JPO	Joint Project Office

JRP	Joint Robotics Program
JSLNBCRS	Joint Services Lightweight NBC Reconnaissance System
JWARN	Joint Warning and Reporting Network
LAR	Light Armored Reconnaissance
LOI	Letter of Instruction
MAA	Mission Area Analysis
MAGTF	Marine Air-Ground Task Force
MCCDC	Marine Corps Combat Development Command
MCM	Mine Countermeasures
MCWL	Marine Corps Warfighting Laboratory
MCWP	Marine Corps Warfighting Publication
MDARS	Mobile Detection Assessment Response System
MEWSS	Mobile Electronic Warfare Support System
MMI	Marine Machine Interface
MNS	Mission Need Statement
MOOTW	Military Operations Other Than War
MOPP	Mission-Oriented Protective Posture
MOS	Military Occupational Specialty
MOUT	Military Operations on Urbanized Terrain
MPF	Maritime Prepositioning Force
MPRS	Man-Portable Robotic Systems
MTW	Major Theater War
NBC	Nuclear, Biological, and Chemical
NEO	Noncombatant Evacuation Operations
NOE	Notion of Employment
NSWC	Naval Surface Warfare Center
OCU	Operator Control Unit
OMFTS	Operational Maneuver from the Sea
ORD	Operational Requirements Document
OTH	Over the Horizon
PDF	Principal Direction of Fire
PMS-EOD	Program Management Office for Explosive Ordnance Disposal
QDR	Quadrennial Defense Review
RACS	Robotics for Agile Combat Support
RAOC	Rear Area Operations Center
RCSS	Robotic Combat Support System
RF	Radio Frequency
ROE	Rules of Engagement
RONS	Remote Ordnance Neutralization System
RSTA	Reconnaissance, Surveillance, and Target Acquisition
R&D	Research and Development
SAC	Study Advisory Committee
SARC	Surveillance and Reconnaissance Center
SBIR	Small Business Innovative Research
SIGINT	Signals Intelligence
SOA	Sustained Operations Ashore

SOMROV	Special Operations Miniature Robotics Vehicle
SOW	Statement of Work
SRS	Standardized Robotic System
SSC	Smaller Scale Contingency
STOM	Ship-to-Objective Maneuver
TACOM	Tank-Automotive and Armaments Command
TCAC	Technical Control and Analysis Center
TCO	Tactical Combat Operations
T/E	Table of Equipment
T/O	Table of Organization
TOE	Theory of Employment
TPCS	Team Portable Communications Intelligence System
TRADOC	Training and Doctrine Command
TRL	Technology Readiness Level
TSPO	Technical Study Project Officer
TUGV	Tactical Unmanned Ground Vehicle
TUV	Tactical Unmanned Vehicle
UAV	Unmanned Aerial Vehicle
UGV	Unmanned Ground Vehicle
UGV/S	Unmanned Ground Vehicle/System
UGVTEE	UGV Technology Enhancement and Exploitation Program
UHF	Ultra High Frequency
URBOT	Urban Robot
USA	U.S. Army
USMC	U.S. Marine Corps
USSOCOM	U.S. Special Operations Command
UXO	Unexploded Ordnance
VHF	Very High Frequency
VSTOL	Vertical Short Takeoff and Landing
WMD	Weapons of Mass Destruction

Appendix C

Definitions

Artificial Intelligence. The programming and ability of a robot to perform functions that are normally associated with human intelligence, such as reasoning, planning, problem solving, pattern recognition, perception, cognition, understanding, learning, speech recognition, and creative response.

Automation. The capability of a machine or its components to perform tasks previously done by humans. Usually accomplished by a sub-system of a larger system or process, performance of tasks can be cued by humans or a point in the process. Examples are an autoloader in an artillery system or the welding of parts on an assembly line by machines.

Autonomous. A mode of control of a UGV wherein the UGV is self-sufficient. The UGV is given its global mission by the human, having been programmed to learn from and respond to its environment, and operates without further human intervention.

Classes of UGVs. The JRP postulates several classes of UGVs, based on weight:

- Micro: < 8 pounds
- Miniature: 8-30 pounds
- Small (light): 31-400 pounds
- Small (medium): 401-2,500 pounds
- Small (heavy): 2,501-20,000 pounds
- Medium: 20,001-30,000 pounds
- Large: >30,000 pounds

Cooperative Operations. The ability of two or more UGVs to share data, coordinate their maneuver, and perform tasks synergistically.

Data Link. The means of connecting one part of the UGV system with another part of the system for the purpose of transmitting and receiving data. Examples of technologies used as UGV data links are radio frequency, fiber optics, and laser.

Electro-Optics (EO) Sensor. An electro-optics device that responds to any received electromagnetic radiation in wavelengths ranging from x-ray to far infrared. An electro-optics sensor typically includes optics, detector, read-out electronics, and data acquisition electronics. If it is an active device, it will also include a transmitter. Depending on the technology employed, the detector/receiver may require the use of a cooling sub-system.

Expendable. A UGV that may be consumed in use and may be dropped from stock record accounts when it is issued or used.

Joint Architecture for Unmanned Ground Systems (JAUGS). An upper-level design for the interfaces within the domain of UGVs. It is a component-based, message passing architecture that specifies data formats and methods of communication among computing nodes. It defines messages and component behaviors that are independent of technology, computer hardware, and vehicle platforms and isolated from mission. JAUGS is prescribed for use by the JRP in the research, development, and acquisition of UGVs.

Line of Sight. (1) Visually, a condition that exists when there is no obstruction between the viewer and the object being viewed. (2) In radio frequency communications, a condition that exists when transmission and reception is not impeded by an intervening object, such as dense vegetation, terrain, man-made structures, or the curvature of the Earth, between the transmit and receive antennas.

Man-Machine Interface. The means by which the human operator interacts with the UGV system. It includes the software applications, graphics, and hardware that allow the operator to effectively give instructions to, or receive data from, the UGV.

Manipulator. In robotics, a mechanism consisting of an arm and an end-effector. It contains a series of segments, jointed or sliding relative to one another, for the purpose of modifying, grasping, emplacing, and/or moving objects. A manipulator usually has several degrees of freedom.

Man Portable. A UGV or components of a disassembled UGV capable of being carried by one man over long distance without serious degradation of performance of his normal duties. The upper weight limit is 31 pounds.

Man Transportable. A UGV usually transported in another vehicle that has integral provisions for periodic handling by one or more individuals for limited distances (100-500 meters). The upper weight limit is 65 pounds per individual.

Marsupial. A design concept for UGVs where a larger UGV carries one or more smaller UGVs, either inside it or attached to it for later deployment.

Mission Module. A self-contained assembly installed on a UGV that enables the unmanned platform to perform functions that have military value. It can be easily installed and replaced by another type of mission module.

Mission Planning. The process by which a human operator devises tactical goals, a route (general or specific), and timing for one or more UGVs. Considerations include terrain, threat, weather, location of friendly forces, fire support, and mission modules. The mission planning process may be accomplished on a computer or OCU for downloading to the UGV.

Mobility. The capability of a UGV to move from place to place, while under any method of control, in order to accomplish its mission or function.

Mode of Control (also Control Mode). The manner by which a UGV gets instructions that govern its actions. Examples are remote control, semiautonomous, etc.

Modularity. The property of flexibility built into a system by designing discrete units (hardware and software) that can easily be joined to or interface with other parts or units.

Navigation. The process whereby a UGV makes its way along a route that it planned, was planned for it, or, in the case of teleoperation, the human operator is sending it.

Negative Obstacle. A terrain feature that presents a negative deflection relative to the horizontal plane of the UGV such that it prevents the UGV's continuation on an original path. Examples are depressions, canyons, creek beds, ditches, bomb craters, etc.

Non-Line of Sight. (1) Visually, a condition that exists when there is an obstruction between the viewer and the object being viewed. (2) In radio frequency communications, a condition that exists when there is an intervening object, such as dense vegetation, terrain, man-made structures, or the curvature of the Earth, between the transmit and receive antennas, and transmission and reception would be impeded. Non-line-of-sight communications implies communication across normally non-line-of-sight distance/terrain. An intermediate ground-, air-, or space-based retransmission capability may be used to remedy this condition.

Obstacle Avoidance. The action of a UGV when it takes a path around a natural or man-made obstruction that prevents continuation on its original path.

Obstacle Detection. The capability of a UGV or its operator to determine that there is an obstruction, natural or man-made, positive or negative, in its path.

Obstacle Negotiation. The capability of a UGV or its operator to navigate through or over an obstacle once it is detected and characterized as negotiable.

Operator Control Unit (OCU). The computer(s), accessories, and data link equipment that an operator uses to control, communicate with, receive data and information from, and plan missions for a UGV.

Payload. The load (expressed in pounds of equipment, gallons of liquid, or other cargo) that the UGV is designed to transport under specified conditions, in addition to its unladen weight.

Plug and Play. The ability to quickly remove one type of mission module from a UGV and replace it with another type, the new mission module being ready for immediate use.

Remote Control. A mode of control of a UGV wherein the human operator, without benefit of video feedback, directly controls on a continuous basis the actions of the UGV using visual line-of-sight cues.

Retro-traverse. A behavior of a UGV in which, having recorded navigation data on where it has been, it autonomously retraces its route to a point where it can continue its mission.

Robot. A machine or device that works automatically or operates by remote control.

Robotics. The study and techniques involved in designing, building, and using robots.

Semiautonomous. A mode of control of a UGV wherein the human operator plans a mission for the UGV, it conducts the assigned mission, and requires human operator intervention only when the UGV needs further instructions.

Teleoperation. A mode of control of a UGV wherein the human operator, using video feedback and/or other cues, directly controls on a continuous basis the actions of the UGV.

Telepresence. The capability of a UGV to provide the human operator with some amount of sensory feedback similar to that which the operator would receive if he were in the vehicle.

Tether. A fiber-optic or other communications cable that connects the OCU to the UGV platform.

Unmanned Ground Vehicle (UGV). A powered, mobile, ground conveyance that does not have a human aboard; can be operated in one or more modes of control (autonomous, semiautonomous, teleoperation, remote control); can be expendable or recoverable; and can have lethal or nonlethal mission modules.

Unmanned Systems. A grouping of military systems, the common characteristic being that there is no human operator aboard. May be mobile or stationary. Includes categories of unmanned ground vehicles (UGVs), unmanned aerial vehicles (UAVs), unmanned underwater vehicles (UUVs), unattended munitions (UMs), and unattended ground sensors (UGSs). Missiles, rockets and their sub-munitions, and artillery are not considered unmanned systems.

Waypoint Navigation. The process whereby a UGV makes its way along a route of planned waypoints that it planned or were planned for it.

Waypoints. Intermediate locations through which a UGV must pass en route to a particular destination.

Zamboni Pattern. The path traveled by a UGV that is elliptical in nature, such that an entire prescribed area is covered by the UGV's mission modules or ground track. Named after an ice re-surfacing machine of the same name used at hockey games.

Appendix D

Master Plan Operational and Support Capabilities

R.1. A clear delineation of command authority options during amphibious operations.

- Revise Joint Publication 3-02.

R.2. The detection, recording, marking, and clearing of lanes from deep- through shallow-water mined areas.

- Support Navy development of mine and obstacle clearance capability from the high-water mark seaward.

R.3. An enhanced information warfare capability.

- Develop technologies for offensive and defensive information warfare.
- Continue to improve ground electronic warfare capabilities in electronic attack, electronic support, and electronic protection.

R.4. The capability to operate from seabases to reduce the footprint ashore.

- Support the Navy in design, development, and acquisition of amphibious ships, maritime prepositioning ships, and assault follow-on echelon ships with the proper configuration to support seabased operations.

R.5. Nonlethal capabilities to support military operations.

- Develop, as the executive agent and in conjunction with the other Services and agencies, nonlethal policies, procedures, technologies, and systems.

R.6. Enhanced force protection capabilities across the operational spectrum.

- Improve force protection capabilities.
- Enhance force protection training.

R.7. A robust command and control/information infrastructure, extending the defense information infrastructure to meet Marine Corps deployed and garrison information requirements to support operations afloat, ashore, and in the air.

- Develop a communication, computing, and common software infrastructure capable of supporting both joint and Service level national security systems and automated information systems.
- Ensure that the Marine Corps infrastructure is fully compliant with the Defense Information Infrastructure Common Operating Environment and accommodates the Joint Technical Architecture.
- Develop command, control, communications, computer, and information capabilities that support our operational concepts and sustain these capabilities with periodic technology enhancements to ensure interoperability with joint standards.

R.8. Reliable, secure, and fully integrated communications capabilities to support over-the-horizon information exchange requirements.

- Develop, in conjunction with the Joint Staff and other Service staffs, command, control, communication, computer, and information systems with sufficient capacity to support operations from the seabase.
- Ensure that the Marine Corps over-the-horizon communication capability is interoperable with naval and joint communication/internet protocols.
- Maintain reliable and secure communications during all phases of operations.

R.9. A set of unit operations centers to enhance situational awareness and decision making.

- Develop visual displays for battlefield information.
- Develop streamlined organizations and procedures.
- Develop standardized field shelters, equipment, and power distribution systems.

R.10. Robust operational and tactical intelligence, reconnaissance, surveillance, and target acquisition capabilities.

- Enhance access to national and theater platforms, intelligence centers, and databases.
- Acquire, operate, and control tactical intelligence, reconnaissance, surveillance, and target acquisition units and systems.

R.11. Effective joint combat identification systems.

- Develop organic combat identification systems that are interoperable with joint systems.
- Continue to pursue non-materiel solutions to combat identification.

R.12. Responsive, accurate, long-range naval surface fires and aviation fire support.

- Support development of naval surface fires of sufficient quantity, range, and lethality.
- Support development of responsive, accurate, night, all-weather aviation fire support.
- Support development of air superiority and air defense capabilities to meet operational requirements.

R.13. Responsive, accurate, and mobile ground fire support systems.

- Develop ground indirect-fire systems that support operational requirements.

R.14. An enhanced family of munitions for ground and aviation operations.

- Develop all-weather munitions with increased lethality, accuracy, and range.

- Develop variable yield aviation munitions for use in urban terrain.
- Reduce munitions logistics requirements.

R.15. Enhanced capabilities to seize deep objectives from the seabases.

- Develop fire support, logistics, command and control, and ground and air mobility systems that support ship-to-objective maneuver.
- Develop the *Tentative Manual for Landing Operations for the 21st Century*.

R.16. The capability to operate effectively at night, in all weather conditions, and on an obscured battlefield.

- Continue to pursue emerging technology to enhance systems for night and all-weather limited visibility conditions.

R.17. The capability to record, mark, detect, clear, avoid, and breach mines and obstacles from the high-water mark inland.

- Develop the equipment and procedures to detect, breach, reduce, clear, record, and mark mines and other obstacles.
- Develop advanced mobility systems to identify, circumvent, or clear mines while on the move.

R.18. An enhanced capability to operate in a nuclear, biological, or chemical environment.

- Enhance organic nuclear, biological, and chemical defense procedures and equipment.
- Enhance Chemical Biological Incident Response Force capabilities.

R.19. Changes in organizational structure to support operations in the 21st Century.

- Review and implement appropriate changes in organizational structure to support emerging concepts.

R.20. Improved ranges to better support required training and comply with environmental regulations.

- Incorporate simulation, instrumentation, and automation into training range upgrades.
- Ensure that operations and training solutions to required capabilities meet applicable environmental regulations.
- Develop training munitions that are compatible with range limitations and environmental restrictions.

R.21. A training and education system that improves operational capabilities and readiness.

- Enhance the training and education systems to deliver timely and relevant instruction and reduce time in training and associated structure.
- Exploit emerging training and education technology.
- Foster a learning environment throughout the Marine Corps.

R.22. Integrated and relevant Total Force Structure programs.

- Continue the Total Force Structure review.
- Enhance supporting establishment mobilization plans.
- Enhance civilian work force training and education.

R.23. An enhanced capability to operate in a riverine environment.

- Improve current small craft capabilities.
- Determine future requirements in support of Unified Commanders.
- Establish a riverine training center to centralize the training, maintenance, and sustainment of riverine forces.

R.24. A littoral warfare training capability.

- Identify littoral warfare training requirements.
- Determine and prioritize associated support and funding requirements.

R.25. The capability to provide seabased logistics.

- Support the development of a concept for seabased logistics that ensures integration with amphibious ships, maritime prepositioned ships, aviation logistics support ships, hospital ships, combat logistics force ships, offshore petroleum discharge systems, and logistics-over-the-shore systems.
- Develop ship-to-objective logistics distribution systems.
- Adapt current and evolving combat service support functions to a seabased environment.

R.26. A total asset visibility logistics system linked to national and theater agencies.

- Develop tactical through strategic asset visibility systems supported by common databases.
- Develop procedures and systems to maintain logistics visibility in maneuver units.

R.27. Enhanced capabilities to deploy, sustain, redeploy, and regenerate forces by strategic air and sealift.

- Develop enhanced force deployment planning and execution systems, procedures, and training.

- Enhance readiness by integrating force deployment planning and execution into exercise plans and schedules.

R.28. An enhanced capability to sustain forward-deployed forces from the supporting establishment.

- Upgrade supporting establishment facilities to better support force deployment and sustainment options.
- Retain Blount Island as the Marine Corps regeneration facility.
- Enhance supporting establishment mobilization plans.

R.29. Aviation facilities that fully support the operating forces.

- Ensure that aviation infrastructure fully supports operational training and aerial port of embarkation requirements.

R.30. An improved environmental compliance program.

- Incorporate the National Environmental Policy Act requirements during training plan development.
- Provide commanders with adequate resources to comply with environmental regulations.
- Emphasize pollution prevention to achieve environmental compliance.

R.31. A recapitalization, outsourcing, and privatization capability.

- Determine Marine Corps recapitalization, outsourcing, and privatization opportunities.
- Improve measures of effectiveness for evaluating recapitalization, outsourcing, and privatization initiatives.
- Optimize energy and environmental considerations in facility design and construction.

R.32. Comprehensive upgrades in quality-of-life initiatives to support Marines, their families, and civilian employees.

- Determine quality-of-life facilities requirements.
- Upgrade existing facilities and build new facilities as required.
- Improve services and programs.
- Enhance civilian work force training and education.

R.33. A quality force of active and reserve Marines and civilian personnel.

- Recruit a force of military and civilian personnel that reflects the diversity of American society.

- Recruit a force capable of fulfilling the wide variety of technical requirements needed in future force structure.
- Ensure equal opportunity for all Marines and civilian employees.
- Preserve and enhance the unique culture of the Marine Corps.

R.34. Enhanced media relations.

- Develop a public affairs strategy that reinforces the Marine Corps image at home and abroad.

R.35. An enhanced over-the-horizon assault capability.

- Determine future over-the-horizon surface and aviation assault support requirements.
- Develop and field expanded aerial and surface refueling capabilities.

R.36. An enhanced capability to operate in an interagency environment that can orchestrate all elements of national power in a unified effort.

- Develop an operational concept.
- Identify and acquire the technologies to execute the operational concept.

Appendix E

Technology Assessment

Methodology

- Generally, assessments are made considering unmanned ground vehicle robotics in three control modes. The first control mode is teleoperation, defined as "A mode of control of a UGV wherein the human operator, using video feedback and/or other cues, directly controls on a continuous basis the actions of the UGV." The second control mode is semiautonomous operation, defined as "A mode of control of a UGV wherein the human operator plans a mission for the UGV, it conducts the assigned mission, and requires human operator intervention only when the UGV needs further instructions." The third control mode is autonomous, defined as "A mode of control of a UGV wherein the UGV is self-sufficient. The UGV is given its global mission by the human, having been programmed to learn from and respond to its environment, and operates without further human intervention."

- Teleoperation technology is considered relatively mature. Teleoperated UGVs have been fielded on a limited basis. Semiautonomous technology is not expected to fully mature until the mid-term (2008-2017). Progress is largely dependent on advanced technology programs ongoing at DARPA, ARL, and other research centers. Autonomous operational maturity is not expected until the far term (2018-2025).

- Robotics technology is broken down into five major technology areas: intelligence; sensors; mobility; command, control, and communications (C3); and human machine interface (HMI). These technology areas are consistent with ongoing AMRDEC robotics technology assessment efforts.

- Where options in the technical approach were allowed by the NOE, the least stressing option was used in the assessment.

- Technology maturity is based on the technology maturity levels shown in Table E-1. Information available on the NOEs at this stage lacks the fidelity to allow technology assessments that distinguish between each of the nine technology readiness levels (TRLs). Therefore, assessments are done using the four maturity levels corresponding to 6.1 through 6.4 funding appropriation categories shown on the left side of Table E-1 below.

Rationale

Intelligence. Intelligence, including perception and cooperative behavior, is assessed at level 1 for autonomous operation since the UGV must be capable of operating independently and in concert with other UGVs with minimum operator intervention. Vehicle intelligence technology required to enable autonomous operation probably will not be mature before 2015 or later. Conversely, intelligence is assessed at level 4 for teleoperation because the UGV is dependent on human operator actions for operation.

Sensors. Sensor technology is assessed at level 2 generally for support to autonomous operation. Sensor research continues to be ongoing in support of a broad range of military operations. Maturity level 3 was assessed for teleoperation even though much room for sensor performance improvement exists for UGV teleoperation, particularly in the areas of operation in low light levels. Maturity level 1 was assessed for "Surveillance" under the Intelligence NOEs due to sensor sophistication required to perform the surveillance task in addition to support of vehicle intelligence.

Mobility. Assessment of mobility technology is done based on employment notion, size, on-board sensors, level of on-board vehicle intelligence, and terrain or MOUT features over which the UGV must maneuver.

Command, Control, and Communications (C3). Technology assessment was generally assessed at level 3 or above except "Deep Reconnaissance" and "Surveillance" NOEs under Intelligence and "Covering Force" and "Stay-Behind Force" NOEs under Force Protection. These capabilities appear to require reliable, jam-resistant, and assured-connectivity communication networks that will not be available in the near term at best.

Human Machine Interface (HMI). HMI technology is assessed at level 3 or 4 except for "Deep Reconnaissance" and "Surveillance" under Intelligence and "Stay-Behind Force" under Force Protection. These NOEs are assessed at level 2 because of HMI criticality. Ongoing development efforts in miniaturization of operator control units, voice command recognition, and others appear to justify these assessments. Further, HMI is dependent on advancement in C3 and vehicle intelligence technology. As UGVs become more intelligent HMI becomes less critical from a UGV functional standpoint. For instance, HMI is highly dependent on quality of communications to successfully teleoperate the UGV. UGV semiautonomous and autonomous operation requires less HMI. Accordingly, technology level 3 is assigned for autonomous and semiautonomous operation. Note: Human intervention, regardless of degree of UGV autonomy, will continue to be required for control purposes.

	NOEs - TECHNOLOGY ASSESSMENT				
	INTELL	**SENSORS**	**MOBILITY**	**C3**	**HMI**
MANEUVER					
1. Point for Infantry	4	3	2	3	2
2. Scout for Mounted Forces	4	4	4	4	4
3. Wingman *(1)*	1	2	3	3	3
4. Amphibious MCM *(2)*	2	3	2	3	3
5. Obstacle Breaching in the Assault	4	4	4	4	4
6. AP Obstacle & Minefield Breaching	4	4	3	4	3
7. Flank Security & Rear Guard	1	2	2 *	3	3
8. Obscurant Dispensing *(3)*	4	4	3	3	3
9. Exploitation/Pursuit	1	2	2	2	3
10. Remote Attack/Ambush	1	2	2	2	3
11. Landing Zone Security *(1)*	1	2	3	3	3
12. Mechanical Mule *(3)*	4	3	2	3	2
13. Assault Bridging	4	4	4	4	4
FIRES					
1. Rifle Squad/Fire Team Base of Fire	4	3	3	3	2
2. Robotic Flamethrower	4	4	4	3	4
3. Infantry Battalion Direct-Fire Support *(3)*	4	3	3	2	2
4. Assault on Fortified Positions *(3)*	4	4	3	4	3
5. Robotic Fwd Observer/Tgt Designator *(1)*	2	2	3	2	3
6. Fire Support System	1	2	3	2	3

LOGISTICS					
1. Convoy Escort *(1)*	2	2	3	2	3
2. Resupply	3	4	4	4	4
3. Amphibious Train & Resupply *(4)*	3	4	4	4	4
4. Materiel Handling Equipment	3	3	3	3	3
5. Artillery Resupply	2	2	3	3	3
6. Firefighting *(3)*	4	4	4	4	4
C2					
1. Communications Relay *(3) (5)*	4	3	3	3	3
2. Air Defense Radar *(3) (6)*	4	3	4	3	3
INTELLIGENCE					
1. Amphibious Reconnaissance *(2)*	1	2	2	3	3
2. Route Reconnaissance	2	2	2	3	3
3. Deep Reconnaissance	1	2	2	2	2
4. Surveillance *(7)*	1	1	3	1	2
5. Close Reconnaissance *(8)*	4	4	3	4	3
6. Robotic OP/LP	4	3	3	3	3
7. Urban RSTA	4	3	2	3	3
8. Long-Term Surveillance *(1) (9)*	3	4	4	3	3
9. Tunnel Reconnaissance & Clearing *(3) (10)*	4	3	3	3	3
10. Electronic Warfare *(11)*	1	2	2	3	3
11. Building Reconnaissance & Surveillance *(12)*	2	2	2	3	3
12. Artillery-Emplaced Surveillance *(13)*	1	2	3	3	3
FORCE PROTECTION					
1. Area Denial UGV	2	2	3	3	3

2. NBC Reconnaissance *(1) (14)*	2	2	2	3	3
3. Operational & Tactical Deception	1	2	2	3	3
4. Covering Force *(15)*	1	2	2	2	3
5. Combat Patrolling *(1)*	2	2	2	3	3
6. Robotic Bunker *(1)*	2	2	3	3	3
7. Stay-Behind Force *(1) (16)*	2	2	3	2	2
8. Urban Warrior	4	3	2	2	2
9. Building Reconnaissance & Clearance *(1) (10)*	2	2	2	3	3
10. Countersniper *(3)*	4	2	2	2	2
11. Automated Sentry	3	3	4	4	3
12. Interior Guard	3	3	4	4	3
13. Bomb Detection/Disposal *(3)*	4	2	3	3	3
14. Teleoperated Engineer Vehicles	4	4	3	3	2
15. Casualty & Equipment Recovery *(1)*	2	2	3	3	3
16. Remote Decontamination *(3)*	4	4	4	4	4
Footnotes:					
(1) Assumes semiautonomous operation.					
(2) Assessment does not address surf effects on mobility.					
(3) Assumes teleoperation.					
(4) Assumes follower, but not leader, in unmanned convoy.					
(5) Assumes airborne communications link to allow teleoperation after insertion in general area.					
(6) Assumes air insertion and airborne communications link to transmit radar returns; maneuver limited to repositioning radar.					
(7) Assumes "long term" means 24 hours or longer, requiring advanced power sources; SAR may not be size compatible.					
(8) Assumes "short range" means line of sight.					
(9) Assumes UGV operating over pre-programmed repetitive route.					

(10) Assumes miniature-sized UGV.				
(11) Assumes miniature size, parafoil delivery (to avoid artillery hardening issue), and activation on schedule.				
(12) Assumes micro size, delivered by covert means, & semiautonomous (to detect & maneuver around obstructions within building).				
(13) Assumes single miniature UGV in specialized container (reduces shock hardening requirement) & autonomous operation.				
(14) Assumes NBC detection, but not classification capability.				
(15) Assumes autonomous operation in order to be employed cooperatively with other UGVs.				
(16) Assumes miniature size or larger to accommodate all desired tasks.				
** "Cross country mobility characteristics **exceeding** those of footmobile infantry" may not be realistic -- needs clarification.*				

Table E-1. Technology Assessment

Appendix F

NOE Prioritization

Prioritization Methodology

A multiattribute utility analysis was used to prioritize NOEs. First, a set of attributes was developed that collectively defined the worth of an NOE in terms of the potential contribution of that NOE to the warfighting capability of the MAGTF. Each attribute was weighted based on the collective subjective judgment of a group of Marine officers. Ten company and field grade officers with a broad cross-section of combat, combat support, and combat service support MOSs performed the weighting in a prioritization seminar conducted on 18 April. The weights were determined by a widely used technique known as the analytic hierarchy process (AHP). AHP uses pairwise comparisons of attributes to establish weights. After determining the weights of attributes, each NOE was then scored attribute by attribute. The scoring of attributes was done by the same set of Marine officers that weighted the attributes. Using the attribute-scoring scheme described below, each Marine assigned a score of 1, 3, or 6 for each NOE for each attribute. The overall score for each concept was then calculated by weighting and summing the scores for each attribute:

Overall Score = $\sum W_i * A_i$

where W_i is the weight of the *i* th attribute and A_i is the score of the concept with respect to the *i* th attribute.

In this process, the most critical step was identifying and clearly defining a set of attributes that reflect how a concept contributes to MAGTF warfighting capability. This included carefully describing how each attribute should be scored. To the extent possible, to avoid inadvertently favoring one NOE over another, the attributes are mutually exclusive. The attributes are:

- Criticality of the task performed by the UGV
- Probability of having to perform the task
- Current ability to perform the task
- Need to perform the task in an unmanned fashion.

Attribute Definitions

- **Criticality of the task.** The importance of successful task accomplishment to MAGTF mission accomplishment.

- **Probability of having to perform the task.** The likelihood of a requirement to perform the task.

- **Current ability to perform the task.** The degree to which the task can currently be accomplished.

- **Need to perform task in an unmanned fashion.** An intrinsic requirement to perform the task in an unmanned fashion (perhaps a particular task is too dangerous to

continue performing in a manned fashion even though, in other respects, it is currently performed in a satisfactory manner).

Attribute Scoring

Seminar participants assigned scores for each NOE to each attribute based on the following criteria:

- **Criticality of the task.**

  - 6 if the task must be performed for the MAGTF to accomplish the mission.
  - 3 if the MAGTF mission can be accomplished without performing the task, but only with increased risk (in terms of mission accomplishment) or cost.
  - 1 if the MAGTF mission can be accomplished without performing the task and without incurring increased risk (in terms of mission accomplishment) or cost.

- **Probability of having to perform the task.**

  - 6 if there is better than a 50% probability that the task will have to be performed by a MAGTF in the next ten years.
  - 3 if there is between 50% and 10% probability that the task will have to be performed by a MAGTF in the next ten years.
  - 1 if there is less than a 10% probability that the task will have to be performed by a MAGTF in the next ten years.

- **Current ability to perform the task.**

  - 6 if the MAGTF cannot currently perform the task.
  - 3 if the MAGTF can currently perform the task, but only at unacceptable risk (in terms of mission accomplishment) or cost.
  - 1 if the MAGTF can currently perform the task with acceptable risk (in terms of mission accomplishment) and cost.

- **Need to perform task in an unmanned fashion.**

  - 6 if performing the task in manned fashion results in an unacceptable risk in terms of casualties.
  - 3 if performing the task in manned fashion results in an acceptable risk in terms of casualties.
  - 1 if performing the task in a manned fashion results in little or no risk in terms of casualties.

Prioritization Results

Ten Marine officers participated in the prioritization. These officers were:

- Capt Mike Lepson, MOS 0402, assigned to workstation 1.
- LtCol Timothy R. Dally, MOS 7509, assigned to workstation 4.
- Maj Timothy B. Seamon, MOS 1302, assigned to workstation 5.
- Maj Ronald F. Woodman, MOS 0302, assigned to workstation 6.
- Capt Sun W. Kim, MOS 0602, assigned to workstation 7.
- Maj Julian V. Dees, MOS 1803, assigned to workstation 8.
- Maj James E. McGinley, MOS 0202, assigned to workstation 9.
- Maj Brian Kerl, MOS 0802, assigned to workstation 10.
- Capt Douglas Zielinski, MOS 0402, assigned to workstation 11.
- Capt Robert Liebe, MOS 7566, assigned to workstation 12.

The composite weights[1] for attributes calculated using AHP were:

- Criticality 0.5173
- Probability 0.1817
- Current Ability 0.1645
- Unmanned Need 0.1365

The composite attribute scores and composite total scores are given in Table F-1 below.

NOE #	Criticality	Probability	Current Ability	Unmanned Need	Total Score
C2-1	5.7	6	2.3	3.2	4.853942
FP-2	5.7	3.2	2.9	5.1	4.703213
M-6	5.7	4.5	2.3	4	4.69058
M-1	5.7	5.7	1.2	3.3	4.632133
FP-9	5.1	4.9	2.3	4.8	4.562112
F-5	5.4	5.1	2	3.7	4.554124
I-5	5.4	4.5	3	3.1	4.527684
FP-13	4.8	4.8	3	4.8	4.503906
I-2	5.4	5.1	2	3.1	4.472216
F-1	5.7	5.7	1	2	4.421766
I-10	5.1	4.6	2.7	3.5	4.395929
F-4	5.4	4.2	2	3.6	4.376929
FP-5	5.4	5.1	1.2	3	4.326967
I-7	4.8	5.4	2	3.9	4.325576
FP-8	4.9	4.6	2.5	3.6	4.273226
I-1	4.8	5.1	2.6	2.9	4.233246
L-3	5.2	5.1	1.6	2.3	4.193752

[1] Individual weighting and scoring for each workstation is available in electronic media.

M-4	4.5	3.3	3.7	4.8	4.191298
M-2	4.5	5.7	2.1	3.1	4.132147
I-4	4.8	4.5	2.3	3.3	4.129474
FP-10	4.5	4.9	2.6	3.5	4.123629
M-5	4.8	4	2.2	4	4.117726
L-2	5.1	5.7	1.2	1.7	4.103347
FP-16	4.8	2.8	3.1	3.8	4.020412
I-6	4.9	4.3	1.9	2.7	3.997151
I-11	4.2	4.3	2.7	4.2	3.971426
M-7	4.9	5.1	1.2	2.2	3.959119
F-3	5.1	4.2	1.2	2.6	3.953636
L-5	5.1	4	1.4	1.9	3.854633
I-3	4.3	3.7	2.5	4	3.853923
C2-2	4.5	3.7	2.3	3.2	3.815268
I-9	4	3.8	2.7	4.2	3.777114
L-4	4.6	5.7	1	1	3.716251
M-11	3.8	4.6	2.7	3	3.655215
FP-14	4.3	4	1.9	2.4	3.591318
L-1	4	4.5	2.1	2.6	3.587195
FP-15	3.9	4.3	1.8	3.2	3.531684
F-6	4	4.2	1.9	2.4	3.472479
FP-12	4	4.9	1.2	1.9	3.416275
FP-11	3.8	5.4	1.2	1.8	3.390026
FP-1	4.3	3.3	1.9	1.8	3.382209
M-8	3.7	4.9	1.4	2	3.307643
M-3	3.5	3.8	2.2	2.7	3.231458
M-9	4	3.5	1.2	2.2	3.202828
FP-4	3.9	3.4	1.2	2.6	3.187534
F-2	2.7	2.1	4.7	4.6	3.17934
M-10	3.2	3.3	2.5	3.4	3.130326
FP-3	3.4	3.2	2.4	2.7	3.103601
I-8	3.5	3.3	1.4	2.9	3.036306
L-6	3.5	3.9	1.4	2	3.022473
M-13	3.1	2.7	2.5	3.2	2.942267
M-12	3.1	3.8	2	2.3	2.937044
FP-6	3.1	2.8	1.4	3.3	2.793144
I-12	2.7	2.6	2.2	3.4	2.695139
FP-7	2.3	2.3	2.4	3	2.412009

Table F-1. NOE Scoring

Converting NOEs to TOEs

The above 55 NOEs were rank ordered by total score. The rank-ordered NOEs are defined as TOEs, and the top-ranking 15 were expanded into COEs in the main body of this report.

Analyzing Scoring of Attributes

At the first IPR, the SAC expressed interest in knowing how the top-ranked NOEs were scored with respect to the "need for unmanned capability" attribute. The SAC felt that this attribute was, in some sense, a sanity check (i.e., if there is no particular need to perform a task in an unmanned fashion, perhaps that NOE is not deserving of consideration even if it has a high overall score). In particular, the SAC requested that the percentage of seminar participants assigning scores of 1 (little or no risk in performing task in manned fashion) for this attribute be noted. This information is presented in the table below. It should be noted that fully half of the respondents identified little or no risk in performing NOE F-1, Squad/Fire Team Base of Fire, in a manned fashion.

NOE #	Total Score	Percentage Scoring Unmanned Need as 1
C2-1	4.853942	20%
FP-2	4.703213	0 %
M-6	4.69058	10%
M-1	4.632133	0%
FP-9	4.562112	0%
F-5	4.554124	10%
I-5	4.527684	10%
FP-13	4.503906	0%
I-2	4.472216	10%
F-1	4.421766	50%
I-10	4.395929	20%
F-4	4.376929	0%
FP-5	4.326967	0%
I-7	4.325576	0%
FP-8	4.273226	0%

Table F-2. Unmanned Need Scoring

Conversion to COEs

The 15 top-ranking TOEs were consolidated with seven lower-ranked TOEs and refined into 13 COEs. The rank order assigned to individual NOEs was lost through this consolidation and refinement process. Consequently, the 13 COEs have no rank order or relative priority.